

The Blast Furnace

Engineering Editor - - - -

EDITORIAL

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Vol. X

CONTENTS FOR

General Reviews

THE STEEL INDUSTRY DURING 1921.....	2
BY R. E. V. LUTY	
REVIEW OF IRON AND STEEL LITERATURE FOR 1921..	4
BY E. H. McCLELLAND	
PROGRESS IN IRON AND STEEL METALLURGY.....	9
BY J. M. HALL	
SKETCH OF THE CAREER OF JOSEPH G. BUTLER, JR....	60

By-Product Coke Oven Department

NEW BY-PRODUCT COKE OVEN PLANTS.....	12
BY J. M. HASTINGS, JR.	
EUROPEAN BY-PRODUCT COKING DURING 1921.....	18
BY A. THAU	
BY-PRODUCT COKE OVEN INDUSTRY IN 1921.....	21
BY C. J. RAMSBURG	

Blast Furnace Department

INTERESTING SINTERING PLANT AT BIRDSBORO, PA..	24
BY B. G. KLUGH	
HOT BLAST STOVE RATING.....	29
BY F. H. WILLCOX	
NEW BLAST FURNACE AT McKEESPORT, PA.....	32
BY DONALD N. WATKINS	
SUPERPOWER PLAN WOULD OVERCOME LARGE WASTE	58
REFRACTORIES IN THE STEEL PLANT.....	100
BY W. A. HULL	

Steel Works Department

RECENT DEVELOPMENTS IN OPEN HEARTH FURNACES	36
BY HENRY WILLIAM SELDON	

PROGRESS OF ELECTRIC STEEL FURNACE.....	37
BY EDWARD T. MOORE	
MANUFACTURE OF COMMERCIALLY PURE IRON.....	41
BY D. M. STRICKLAND	
THE ACID ELECTRIC STEEL PROCESS.....	43
BY R. J. WEITLANER	
OPEN HEARTH FURNACE MAKES A RECORD.....	48
GRAPHICAL TREATMENT OF STACK GAS ANALYSIS AND FUEL GAS ANALYSIS	50
BY W. TRINKS	
REFRACTORIES IN THE STEEL PLANT.....	100
BY W. A. HULL	
EFFECT OF SULPHUR AND OXIDES IN ORDNANCE STEEL	96
BY WILLIAM J. PRIESTLEY	
THE MANSFIELD SHEET & TIN PLATE COMPANY'S NEW STEEL UNIT.....	71
BY CARL W. PEIRCE	
THE INFLUENCE OF GAS CLEANING ON PLANT ECONOMY	89
BY WALTER N. FLANAGAN	

Rolling Mill Department

ELECTRIC DRIVES FOR WIRE MILL.....	64
AMERICAN ROLLING MILLS FOR FRANCE.....	68
THE MANSFIELD SHEET & TIN PLATE COMPANY'S NEW STEEL UNIT.....	71
BY CARL W. PEIRCE	
HAMMER WELDING STEEL PIPE.....	34
HEATING FURNACES FOR FORGINGS.....	94
BY CARL FISCHER	
RECENT DEVELOPMENTS IN STEEL MILL CRANES....	22
BY GORDON FOX	
ELECTRICAL REVIEW OF THE STEEL INDUSTRY.....	111
BY O. NEEDHAM	

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JANUARY, 1922

No. 1

Structural Department

AMERICAN ROLLING MILLS FOR FRANCE.....	68
HAMMER WELDING STEEL PIPE.....	34

Mechanical Department

RECENT DEVELOPMENTS IN STEEL MILL CRANES....	22
BY GORDON FOX	
ELECTRIC DRIVES FOR WIRE MILL.....	64
SLOSS SHEFFIELD STEEL & IRON COMPANY'S STEAM GENERATING STATION	83
BY M. M. ARGO AND H. MAULSHAGEN	
WITH THE EQUIPMENT MANUFACTURERS.....	106

Production Topics

PRODUCTION NOTES	105
THE STEEL INDUSTRY DURING 1921.....	2
BY B. E. V. LUTY	

Digest of Technical Literature

REVIEW OF IRON AND STEEL LITERATURE 1921.....	4
BY E. H. MCLELLAND	
EDITORIAL INDEX OF BLAST FURNACE AND STEEL PLANT FOR YEAR 1921.....	Colored Insert

Power Department

POWER IN THE STEEL INDUSTRY DURING 1921.....	78
BY F. J. CROLIUS	
SLOSS SHEFFIELD STEEL & IRON COMPANY'S STEAM GENERATING STATIONS	83
BY M. M. ARGO AND M. MAULSHAGEN	
THE INFLUENCE OF GAS CLEANING ON PLANT ECONOMY	89
BY WALTER N. FLANAGAN	
HEATING FURNACES FOR FORGINGS.....	94
BY CARL FISCHER	

SUPERPOWER PLAN WOULD OVERCOME LARGE WASTE	58
---	----

ELECTRICAL REVIEW OF THE STEEL INDUSTRY.....	111
BY O. NEEDHAM	

NEW FLUE GAS FILTERING SYSTEMS.....	92
-------------------------------------	----

Forging and Heat Treating Department

THE ACID ELECTRIC STEEL PROCESS.....	43
BY R. J. WEITLANER	

HEATING FURNACES FOR FORGINGS.....	94
BY C. FISCHER	

EFFECT OF SULPHUR AND OXIDES IN ORDINANCE STEEL	96
BY WILLIAM J. PRIESTLEY	

REFRACTORIES IN THE STEEL PLANT.....	100
BY W. A. HULL	

PROGRESS IN IRON AND STEEL METALLURGY.....	9
BY J. M. HALL	

GRAPHICAL TREATMENT OF STACK GAS ANALYSIS AND FUEL GAS ANALYSIS	50
BY W. TRINKS	

MANUFACTURE OF COMMERCIAL PURE IRON.....	41
BY D. W. STRICKLAND	

Miscellaneous Department

NEWS OF THE PLANTS.....	105
WITH THE EQUIPMENT MANUFACTURERS.....	106
FOREIGN RELATIONS	107
OPEN HEARTH	108-9
PRODUCTION TOPICS	110-11
TRADE NOTES, TRADE PUBLICATIONS.....	112

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The Blast Furnace *and* Steel Plant

Vol. X

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No. 1

Future Success Depends Upon Improved Methods of Production

DURING the five years preceding 1921, the whole thought of those in charge of the iron and steel industry was production, and technical developments were of secondary consideration. During all this time the engineers and operating officials pleaded only for a breathing spell, in which time obsolete and worn-out equipment could be replaced, new plants constructed, and new developments completed.

The year 1921 brought forth this very opportunity, as the steel industry was at low ebb. Consequently, no year in the history of the industry has been more replete with engineering activities, no year has seen greater interest displayed in improvements, and in no year has there been more definite applicable knowledge disseminated. These facts afford a material foundation for a spirit of optimism which is the dominant element in the expansion of industry.

Industrial depression constitutes an incentive to economize in materials, stimulates efforts to improve methods of production, and checks numerous minor wastes which inevitably develop in times of intense industrial activity. Thus a period of depression is not an unmitigated evil; such a period merely represents the inertia inherent in readjustment of the industrial structure, and recent conditions should have a salutary effect in stabilizing the mechanism of industry.

We therefore predict that the greatest advances in the history of the industry will take place during the next few years, and confidently look forward to an early resumption of activity and a revival of prosperity in the iron and steel industry.

The Steel Industry During 1921

Depression in Steel Industry During the Past Year Due to the Liquidation of Material in Intermediate Hands, Rather Than a Cessation of Consumption by the Ultimate User.

By B. E. V. LUTY

IT GOES without saying that the year 1921 was a year of "readjustment" in the iron and steel trade, as it was in all commercial lines. One scans a year of history to see what has been accomplished, so 1921 is to be studied to see what progress was made in this readjustment.

It is palpably plain that the iron and steel industry completed its readjustment as far as lay in its power. The iron and steel consuming industry did not do as much—not, probably, because it did not try as hard, but because it was controlled in part by circumstances over which it had no control.

That is, the steel producing industry reduced its prices to a very fair level, and did not consume anything like all of the year in doing so, but the consumers, those to whom the steel industry sells, were in control of those to whom they in turn sell, and the ultimate consumer or investor did not get in position to take hold freely. The result was a restricted market.

Course of Steel Prices:

The year of 1921 being largely a year of "readjustment" and as the word as lately used connotes price readjustment more than any other one particular thing, the course of steel prices deserves first consideration in a review of the year. A composite finished steel, or weighted average of the important finished steel products, devised by the writer, permits a study of price movements without use of a complicated mass of figures. The composite is made up of 2½ pounds each of shapes, plates, wire nails and pipe, one pound of sheets and a half pound of tin plate. In dollars and cents per net ton this composite finished steel has been as follows:

Ten-year average, 1904-1913.....	\$36.00
1913 average	34.40
Low, December, 1914.....	28.40
High, July, 1917.....	116.00
Government war control.....	76.00
Industrial Board, March 21, 1919..	65.00
High, August, 1920.....	77.00*
January 1, 1921.....	65.00
December 31, 1921.....	45.20

It will be recalled that the prices set by agreement between the steel makers and Secretary Redfield's Industrial Board, four months after the armistice, were announced as being prices that were fair for everyone to proceed upon. They averaged \$11 a ton under the control prices of the government during the war. At first the prices seemed to many buyers to be too high. Afterwards, in 1920, prices of independents advanced much

*Average of Steel Corporation prices, independent prices for forward delivery and independent prices for prompt delivery.

higher, while the Steel Corporation held to the Industrial Board prices. Late in 1920 the independents returned to the Steel Corporation prices, so that 1921 opened with the steel market precisely at the old Industrial Board level. During the year steel prices fell approximately one cent a pound, and more than three-fourths of this decline occurred during the first seven months of the year.

As time passed the perspective in which the existing price level of steel products was viewed underwent a fundamental change. When prices first began to decline from the war control they were considered from the viewpoint of how much they had declined. Men saw only the war prices and used them as the standard. There were men who professed to be shocked at the temerity of anyone who thought of comparing prices with those existing before the war. In the course of time the perspective changed, and in 1921 men had no patience with comparisons showing how much prices had declined. What they were interested in was the amount by which prices were higher than pre-war levels. The above presentation of finished steel prices enables all desirable comparisons to be made. Steel prices in December, 1921, were 26 per cent above the 10-year pre-war average, 31 per cent above the 1913 average and 59 per cent above the 1914 low, which was the lowest since 1898 and only a trifle above the low point in all the history of the steel industry.

The Bureau of Labor's index number of prices of all commodities at wholesale is regarded as the best weighted of all the index numbers, and the bureau's practice of making all its comparisons by reference to the average of 1913 fully sanctions this basis. The bureau's index number declined to about 150 (1913=100) by the middle of 1921, and hovered around that level during the second half of the year. Correspondingly finished steel would stand at 131, or 19 points below commodities in general. Thus steel has carried its liquidation farther than other commodities on an average. That is not all the story. There has been liquidation in everything but freight rates, and freight rates are an important part of the cost of making pig iron and steel. The advance in the freight rates that apply to the iron and steel industry was greater than the advance in freight rates in general. Handicapped by having a large part of its cost in an entirely unliquidated item, the steel industry has gone beyond industries in general in liquidating its prices.

Production.

Production of pig iron in 1921 was approximately 16,500,000 gross tons of pig iron and a trifle less than 20,000,000 gross tons of steel ingots, the production of finished rolled steel, in bars, shapes, plates, pipe, wire rods, sheets, etc., being slightly under 15,000,000 gross tons or between 16,000,000 and 17,000,000 net tons.

These estimates compare with officially reported production (gross tons) as follows:

	<i>Pig Iron</i>	<i>Ingots</i>
1890.....	9,202,703	4,250,000
1900.....	13,789,242	10,000,000
1910.....	27,303,567	25,154,089
1913.....	30,966,152	30,284,130
1916.....	39,434,797	41,401,917
1917.....	38,621,216	43,619,200
1918.....	39,054,644	43,051,022
1919.....	31,015,364	33,694,795
1920.....	36,925,897	40,881,392
1921.....	16,500,000	19,500,000

The steel market has been quite accustomed to ups and downs. It has required very little, apparently, in the past to send prices upward and just as little to send them downwards. Right in the middle of the industrial depression of 1893 to 1898 the steel market had a sharp upward swing, in the latter part of 1895, afterwards called "the soda-water rise." Afterwards, to the opening of the World War in 1914, the market had five upward swings and as many downward swings. Each time, when prices were found to be higher than buyers would continue to support, it has been sapiently remarked in the trade that buyers did not have large stocks of steel, hence it would not take long to readjust—the buyers would soon be back in the market again. Each time the appraisal was found to be wrong. The buyers did have large stocks. At the beginning of 1921 the observation was made with redoubled confidence. Certainly this time buyers had not loaded themselves with steel, for prices were exceptionally, dangerously and discouragingly high in 1920. It was found, however, that if anything the condition as to stocks was worse than ever, for not only were there large stocks of unused steel in the hands of buyers, both jobbers and manufacturing consumers, there were also large stocks of manufactured goods, of tools, machinery, agricultural implements and all sorts of things. All these stocks had to be liquidated or passed on to the ultimate consumer or user. During the process the production of steel dropped, at about the middle of July, to less than 20 per cent of capacity, a rate of just 10,000,000 tons of ingots a year.

There is no question that this represented liquidation of material in intermediate hands, not a cessation of consumption by the ultimate user. The people had not stopped doing things. Probably the best general measure of the commercial activity of the country is the bank debits reported by the Federal Reserve Board, the total of debits to individual accounts at banks. These debits show the volume of business being done. In the four weeks ended July 20, 1921, the bank debits showed a lag of only 19 per cent below the debits in the same period of 1920. This was the money turnover, and as prices, salaries, wages, dividends, etc., had increased more than 19 per cent the physical volume of business was greater. The production of steel ingots, by comparison, showed a lag of no less than 75 per cent. Obviously the ultimate consumption or employment of steel did not decrease by three-fourths.

Details of Production.

The year 1921 opened with production of steel ingots at the rate of 29,000,000 tons a year. Except for a slight recovery in May there was a steady decline to the 10,000,000-ton rate of mid-July. Then there was a fairly steady recovery until a rate of slightly over 25,000,000 tons was reached at the end of October. In the last two

months of the year there was a slight tapering off, this being merely a reflection of the season of the year. In the closing months of the year consumption or employment of steel was, except for seasonal influences, at a rate represented by about 25,000,000 tons of ingots a year.

Ordinarily the distribution of production among the different finishing branches of the industry varies but little from one year to another, but in 1921 the relative tonnage of the various finished products showed quite an unusual alignment. Of course, there have been some great variations over long periods. For instance, there was a heavy production of rails in 1887, and it was not until 1899 that as large a production was made, yet meanwhile the production of pig iron doubled. Structural shapes rose from practically nothing to a very substantial tonnage. In 1906 rod production was half the rail production, while in 1914 rods passed rails and have stayed ahead ever since. These, however, are long range comparisons.

The times are unsettled and no one can say just what men will be busy about in future, so that it is impossible to determine just how abnormal was the distribution of steel in the different finished products in 1921, but taking the average of the preceding 10 years as a standard, it may be said that the proportion of steel passing into welded tubular products, particularly oil country goods, into sheets and into wire products, was abnormally large, while the proportion passing into bars, shapes and plates was abnormally small. The proportion of steel passing into rails was practically normal, much loose talk in and out of the trade to the contrary notwithstanding. This point could be dwelt upon and the matter elucidated in detail, but it is not worth while to discuss so unimportant a subject as rails. In a normal year the tonnage of rails required for replacements on the regular steam roads will approximately equal the tonnage of tin plate, a material that sells for two and a half times as much per ton as rails. Production of tin plate was relatively light in 1921, not because ultimate consumption was light, but because large stocks of goods prepared in tin plate containers had been carried over from 1920, partly because the holders shrank from taking the losses they were ultimately forced to accept.

Barometers and Percentages.

Many a true word is spoken in jest, and this perhaps refers in particular to a remark of the late Josh Billings, that "It's a great deal better not to know so many things than to know so many things that ain't so." Also it has been observed that a little knowledge is a dangerous thing. This is apropos the adage that "iron (or steel) is the barometer of trade" and the continued talk of the steel industry operating at this or that percentage. In the last four months of 1921 the steel industry operated at various rates between 30 and 50 per cent of its capacity. Men who had been taught to believe that steel was the barometer and who were told that steel was running at these low percentages were disposed to adopt the view that trade, or commerce in general, was at a very low ebb. Bank debits, already referred to above, ran throughout 1921 at a lag of between 15 and 20 per cent below those of 1920, while on account of the decrease in prices, salaries and wages, the lag in total volume of commerce must have been less than this, and probably showed an increase rather than a lag. Men in general, however, have not been taught to study bank debits. Freight ton-mileage on the railroads, despite the alleged great handicap of high freight rates,

was 75 per cent as great in the first eight months of 1921 as in the first eight months of 1920, when lower freight rates were in effect.

If steel were considered in terms of tons instead of terms of per cent the index would be more trustworthy. The percentage comparison tacitly assumes that whatever steel making capacity exists must operate substantially full, preferably with orders banked up and consumers waiting for deliveries, or the commerce of the country is in bad condition. The people of the United States, however, can do only so much work. If they do more of one kind they must do less of another. Greater results can be accomplished with the same amount of work if efficiency is increased through improvements in methods and appliances, but on account of the war there has been less advancement in the past few years than formerly. The 1920 census showed an increase, over 1910, of 9 per cent in the number of persons gainfully employed. It is a question whether the quantity of work per person increased at all. In 1910, which was a record year in its time, the United States produced 25,154,087 tons of ingots. A 20 per cent increase in 12 years, when the number of workers increased only 9 per cent in ten years, would make 30,000,000 tons of ingots, and that would be a 57 per cent operation of the steel industry. The 30,000,000 tons would look good, the 57 per cent would look bad.

The country can call for steel at such a rate as will require more than a 30,000,000 ton production on either of two bases: First, that by increases in efficiency of fabrication and utilization more steel can be handled by

the same number of persons than in 1910; second, that by doing less work of other descriptions more work can be done in using steel. There does not seem to be any other method.

In the past there have been changes of both descriptions, whereby the tonnage of steel has grown rapidly. Lumber and brick have been replaced by steel in the erection of buildings. Just now building trades labor is engaged chiefly in erecting garages and dwelling houses, which consume little steel in proportion to the work done, rather than bridges, factories, skyscrapers and power plants, which require a great deal of steel. The railroads are striving for greater freight moving capacity by increasing the efficiency, moving a freight car more miles per day, rather than adding largely to the number of cars occupying tracks. The oil industry on the other hand is using steel very freely, for the production of oil must be kept up and year by year it requires more steel to produce a given quantity of oil. The labor involved per ton of steel employed is relatively small.

The foregoing argument is very general in character. It is made, not as a finality, but merely to suggest a general principle that seems to be rarely recognized. The argument has one loose end in particular. The average farmer does have some spare time, and can consume more steel than he has consumed lately, without neglecting other kinds of work, but what the farmer does need before being in position to consume steel freely is higher prices for his products or lower prices for the things he buys.

Review of Iron and Steel Literature for 1921

A Classified List of the More Important Books, Serials and Trade Publications During the Year, With a Few of Earlier Date, Not Previously Announced.

By E. H. McCLELLAND
Technology Librarian, Carnegie Library of Pittsburgh

THIS, the fourth annual review of the literature of iron and steel prepared for THE BLAST FURNACE AND STEEL PLANT, lists a greater number of publications than any preceding review. This is, in part, due to the increasing number of trade publications, many of the more meritorious of which have been included in the classified list below. Due to the praiseworthy efforts of the manufacturers issuing these publications, the literature of the year has been notably enriched.

Where possible, the works listed have been personally examined by the compiler of this review. Certain publications, however, were not available and the only information regarding them was in reviews in technical journals, which in many cases failed to give adequate data.

A few book reviews are referred to below. Many others are listed in the *Technical Book Review Index* published quarterly by the Carnegie Library of Pittsburgh.

The best guide to the extensive current literature of ferrous metallurgy is the *Journal of the Iron and Steel*

Institute, two recent volumes of which are mentioned below.

GENERAL.

Geology, Metallurgy, Testing.

Aal, N. H.—Diagrammes d'équilibre de transformation des aciers spéciaux. 27 pages. 1921. Gauthier-Villars, Paris.

Aitchison, Leslie—Engineering Steels. 397 pages. Macdonald & Evans, London. 25 sh. net.

"Briefly explains how this or that steel is made; what are the special qualities and features of the available varieties, with their chemical proportions, peculiar physical and mechanical properties, and how all these factors contribute to the usefulness of the several grades or limit their application to practical ends."—*Ironmonger*, Sept. 3, 1921, p. 100.

American Institute of Mining and Metallurgical Engineers—Pyrometry. 701 pages. 1920. The Institute, New York.

A symposium at Chicago meeting, September, 1919. Contains some 60 papers, with considerable discussion.

American Iron and Steel Institute—Year Book. 536 pages. 1921. The Institute, New York.

Contains papers at meetings of May and October, 1920.

American Rolling Mill Company—Armco in Picture and Fact. 1921. The Company, Middletown, Ohio.

"A non-technical and pictorial description of the manufacture of iron and steel, and containing, besides general reference data, computing tables, and other useful information, for sheet-metal workers."—*Iron and Coal Trades Review*, Sept. 2, 1921, p. 304.

American Rolling Mill Company—Research and Methods of Analysis of Iron and Steel at Armco. Ed. 2, 220 pages. 1920. The Company, Middletown, Ohio. \$4.

Includes sections on corrosion, magnetic testing, and metallurgical control, including microscopical and physical testing.

American Society for Testing Materials—A. S. T. M. Standards, Issued Triennially. 890 pages. 1921. The Society, Philadelphia.

Devotes 378 pages to ferrous metals, and has sections also on coal and coke, preservative coatings, testing of metallic materials, and preparation of micrographs.

Association of Iron and Steel Electrical Engineers—Proceedings, Thirteenth Annual Convention, 1920. 700 pages. 1921. The Association, Pittsburgh. \$5.

An important feature of the present volume is a symposium on steam-driven vs. electrically driven mills, with charts of high technical value.

Backert, A. O.—A B C of Iron and Steel. Ed. 4. 408 pages. 1921. Penton Publishing, Co., Cleveland. \$5.

Collection of monographs by various authors. In Ed. 4, treatment of rolling mill industry is extended, and chapters are added on manufacture of rails, tubes, and tin-plate. The directory of steel works has been revised and is of great value.

Binz, A.—Kohle und Eisen. Ed. 2. 120 pages. 1919. Tuelle & Meyers, Leipsic. 250 marks.

Brooks, Alfred H. and La Croix, M. F.—Iron and Associated Industries of Lorraine, the Sarre District, Luxemburg, and Belgium. 131 pages. 1920. (United States Geological Survey. Bulletin 703.) Government Printing Office, Washington, D. C.

In addition to statistical and economic information, considers geology and metallurgy.

Carnegie Steel Company—Blast Furnace Slag; Data on Its Preparation, Properties and Commercial Uses. 38 pages. 1921. The Company, Pittsburgh.

Shows value as concrete aggregate, for ballast, and in road construction.

Carnegie Steel Company—General Statistics and Special Treatise on Homestead Steel Works. 60 pages. 1921. The Company, Pittsburgh.

Pamphlet, illustrating equipment and outlining processes at Homestead.

Carnegie Steel Company—Industrial Wheels, Gear Blanks and Other Circular Forgings. 45 pages. 1921. The Company, Pittsburgh.

Comite des Forges de France—La Siderurgie Francaise, 1864-1914. 626 pages. 1920. Paris.

Copper Clad Steel Company—Aristos "Copperweld" Copper Clad Steel Wire. 99 pages. 1921. The Company, Rankin, Pa.

Dichmann, Karl—Die basische Herdofenprozess. Ed. 2. 278 pages. 1920. Julius Springer, Berlin. 50 marks.

Durand, A.—Organisation et conduite des aciéries Martin. Part I: Les Gazogènes. Librairie de L'Usine, Paris. 6 francs.

Reviewed in *La Fonderie Moderne*, Jan., 1921, p. 16.

England—Geological Survey—Special Reports on the Mineral Resources of Great Britain.

Vol. 8: Iron Ores (Contd.), Precarboniferous and Carboniferous Bedded Ores of England and Wales; by Sir A. Strahan and others. 123 pages. 1920. 7 sh. 6 d. net.

"It is here brought out clearly that the production of iron ore from the coal-measures is now of trifling importance, and though much smelting is still done in the coal fields, this is solely because of the presence of coal and not of iron ore."—*Geological Magazine*, Feb., 1921, p. 86.

England—Research Department—Effect of Overstrain on the Elastic Properties of Steel. 1920. (Report No. 45.) H. M. Stationery Office, London. 2 sh. 1 d. postpaid.

Gages, L.—Cours de métallurgie. Ed. 2. 5 vol. 1920-21. Librairie de l'Enseignement Technique, Paris.

v.1: La fonte. 334 pages. 20 fr.

v.2: Elaboration des fers et des aciers. 351 pages.

v.3: Travail des fers et des aciers. 431 pages.

v.4: Essais mécaniques des fontes, des aciers et des fers. 320 pages.

v.5: Métallurgie des alliages métalliques et des métaux autres que le fer. 432 pages.

A comprehensive work, vol. 1-2 of which were listed in this Review for 1920.

Galassini, Alfred—Elementi di siderurgia e di tecnologia meccanica. 669 pages. 1920. Società Tipografica, Turin. 50 lire.

Geuze, L.—Traité theorique et pratique du laminage du fer et de l'acier. Ed. 2. 2 vols. 1921.

Vol. 1: Text. 280 pages.

Vol. 2: Plates (84).

Hall, William T. and Williams, R. S.—Chemical and Metallographic Examination of Iron, Steel and Brass. 501 pages. 1921. McGraw-Hill Book Co., New York. \$5.

A selection of rapid and accurate chemical methods occupies the greater part of the book. Some 30 pages are devoted to electrometric methods and about 100 pages to metallography of iron and steel.

Horner, J. G.—Smithing and Forging. 1921. Emmott & Co., London. 8 sh. 6 d.

Hoyt, Samuel E.—Metallography. Part 2: The Metals and Common Alloys. 462 pages. 1921. McGraw-Hill Book Co., New York.

Part 2 describes metals and alloys, devoting 297 pages to "Steel and Cast Iron" and "Special Steels." Part 1 deals with "Principles," and Part 3 (in preparation) with "Technical Practice."

Institution of Automobile Engineers—Report of the Steel Research Committee Founded by the Institution of Automobile Engineers and the Society of Motor Manufacturers and Traders on an Investigation Conducted to Establish the Mechanical Properties of the British Standard Wrought Automobile Steels, and Factors Governing Testing Procedure in Connection Therewith. 72 pages. 1920. The Institution, Sheffield. 32 sh.

Deals with ten standard automobile steels.

Iron and Steel Institute—Journal. Vol. 102. 423 pages. 1920. Vol. 103. 524 pages. 1921. The Institute, London.

Containing original papers on ferrous metallurgy and numerous abstracts of the current literature in all languages.

Moldenke, Richard—Charcoal Iron. 64 pages. 1920. Salisbury Iron Corporation, Lime Rock, Conn.

History and metallurgical information.

Pickands, Mather & Company—Cargo Analyses; Lake Superior Iron Ores, for Season 1920. 19 pages. 1921. The Company, Cleveland.

Portevin, A.—Pyometrie. Cementation. 1920. Charles Lavauzelle, Paris.

Preuss, E.—Die praktische Nutzenanwendung der Pruefung des Eisens durch Aetzverfahren und mit Hilfe des Mikroskops. Ed. 2. 131 pages. 1921. Julius Springer, Berlin.

Roesler, Max—Iron Ore Resources of Europe. 152 pages. 1921. Government Printing Office, Washington, D. C. (United States Geological Survey. Bulletin 706.) Accompanied by maps. Bibliography of 25 pages.

Sauer, K.—Leitfaden der Huettenkunde fuer Maschinentechniker. 1920. Julius Springer, Berlin.

Spurr, J. E., ed.—Political and Commercial Geology, and the World's Mineral Resources; a Series of Studies by Specialists. 562 pages. 1920. McGraw-Hill Book Co., New York. \$5.

Technical and economic study. Has a chapter of some 35 pages on iron, and chapters on the various metals employed in alloy steels. A very valuable book.

Stainless Steel; Its Properties and Uses. 1921. Brown Bayley's Steel Works, Ltd., Sheffield, England.

Pamphlet for the assistance of those interested in manufacturing wares of stainless steel. Gives composition and properties of several brands, considering also Brearley's "stainless iron."

Standard Alloys Company—Uranium in Steel. 32 pages. 1921. The Company, Pittsburgh.

Discusses uranium, its influence on steel, analytical methods, and physical tests of uranium steel.

Steel Company of Canada, Ltd.—Standard Specifications. 84 pages. 1920. The Company, Hamilton, Ont.

Reprint of various specifications of American Society for Testing Materials, Lloyd's Register, Master Car Builders' Association and Manufacturers' Standards.

Tafel, Wilhelm—Walzen und Walzenkalibrieren. 228 pages. 1921. Wilh. Ruhfus, Dortmund. \$2.25.

Theoretical work, with 161 illustrations and 8 folding plates. Reviewed in BLAST FURNACE AND STEEL PLANT, Sept., 1921, p. 570.

United States Steel Corporation—Chemists' Committee—Methods of the Chemists of the United States Steel Corporation for the Sampling and Analysis of Ferro-Alloys and Bearing Metals. 71 pages. c1920. J. M. Camp, Carnegie Building, Pittsburgh.

Van Dyke, G.—Shop Handbook on Alloy Steels; a Technical Subject Treated in a Non-Technical Way. 95 pages. 1921. Joseph T. Ryerson & Son, Chicago.

Useful manual by manager, Special Steel Department. Outlines manufacture, gives suggestions for use of alloy steels and includes certain specifications and tables.

Verein Deutscher Eisenhuettenleute.—Gemeinfassliche Darstellung des Eisenhuettenwesens. Ed. 11. 594 pages. 1921. Verlag Stahleisen, Dusseldorf. 60 marks.

Vulcan Crucible Steel Company—High Grade Tool Steels and Special Steels. 94 pages n. d. (Catalogue No. 6.) The Company, Aliquippa, Pa.

Gives suggestions for use.

Willem, Jules—Traité elementaire de metallurgie et de technologie metallurgique. New. ed. revised. 365 pages. 1920. P. Martino, Seraing, France. 30 fr. 75.

Greater part is devoted to ferrous metallurgy. Contains folding plates.

Wuest, Fritz, ed.—Mitteilung aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung zu Duesseldorf.

1920. Verlag Stahleisen, Duesseldorf.

Economics and Statistics.

American Hardware Jobbers' Directory of the United States and Canada, and Trade Name Index. Seventh annual edition. 268 pages. 1920. E. G. Baltz, Pittsburgh. \$2.50.

Cotter, Arundel—United States Steel; a Corporation With a Soul. 312 pages. Doubleday, Page & Co., Garden City, N. Y. \$3 net.

Revision and enlargement of author's "Authentic History of the United States Steel Corporation." 1916.

Grabe, Alf., comp.—Iron and Steel in Sweden. 183 pages. 1921? Swedish Chamber of Commerce in the United States, New York.

Information regarding iron and steel and their products available for export.

Lloyd, D. W. and Barnett, A. P., ed.—Business Prospects Year Book. 1921. Business Statistics Co., Cardiff. 10 sh. net.

British annual, summarizing the business outlook in various industries, including iron and steel.

Metal Statistics. Ed. 14. 560 pages. 1921. American Metal Market Co., New York. \$1.

A valuable annual, characterized by promptness in appearance, and by concise arrangement. Presents an immense amount of statistical information on ferrous and non-ferrous metals.

Mineral Industry During 1920. 907 pages. 1921. McGraw-Hill Book Co., New York. \$10.

Section on iron and steel by E. F. Cone contains statistics and review of technical progress during 1920.

Northern Coal, Iron and Steel Companies. Business Statistics Co., Cardiff. 1 sh. 8 d. postpaid.

Annual booklet, giving financial statistics of British companies. Primarily for the investor.

Pawlowski, Auguste—La Metallurgie du fer dans le nord et l'est envahis; hier, aujourd'hui, demain. 288 pages. 1920. L'Information Universelle, Paris.

Reviewed in *La Nature*, March 19, 1921, sup. p. 96.

Peters, Richard, Jr.—Two Centuries of Iron Smelting in Pennsylvania. 79 pages. 1921. Pulaski Iron Co., Philadelphia.

Valuable historical information.

Pothmann, Wilhelm—Zur Frage der Eisen- und Manganerzversorgung der deutschen Industrie. 312 pages. 1920. 24 marks.

Reviewed in *Stahl und Eisen*, October 21, 1920, p. 1430.

South Wales Coal and Iron Companies. 1921. Business Statistics Co., Cardiff. 2 sh. 6 d. postpaid.

British booklet, published annually. Financial statistics of companies, primarily for investors.

Coke.

Biddulph-Smith, Thomas—Coke-Oven and By-Product Works Chemistry. 180 pages. 1921. Charles Griffin & Co., London. 21 sh. 6 d.

Concise British manual for chemical control of plants.

Carnegie Library of Pittsburgh—By-Product Coking; References to Literature, May 1915-June 1921, Supplementing a List Compiled in the Technology Department and Published in the Monthly Bulletin of the Library, May, 1915. 18 pages. 1921. The Library, Pittsburgh.

Mimeograph copy.

Christopher, J. E. and Byrom, T. H.—Modern Coking Practice. Ed. 3. 2 vol. Crosby, Lockwood & Son, London. \$8.

Vol. 1: Raw Materials and Coke. 130 pages.

Vol. 2: By-Products. 130 pages.

Daniels, Joseph—The Coking Industry of the Northwest. 35 pages. 1920. University of Washington, Seattle. (Engineering Experiment Station Series. Bulletin 9.)

Deals especially with the industry in Washington and British Columbia, and with undeveloped resources of Oregon and Alaska.

Electric Furnace.

Borchers, Wilhelm—Die elektrische Ofen. Ed. 3. 289 pages. Wilhelm Knapp, Halle a. Saale.

Dickmann, Herbert—Bibliographie ueber die Darstellung des Roheisens im elektrischen Ofen. 15 pages. 1921. Verlag Stahleisen, Duesseldorf. 6 marks.

Includes literature in books and journals, 1899-1920. Reviewed in *Stahl und Eisen*, Aug. 18, 1921, p. 1169.

Electric Furnace Association—Refractories for Electric Furnaces. 80 pages. 1921? The Association, Niagara Falls, N. Y.

Papers and discussions at meeting of Oct. 6, 1920.

Escard, Jean—L'Electrometallurgie du fer et de ses alliages. 811 pages. 1920. Dunod & Pinat, Paris. 45 francs.

Discusses the electric furnace in steel manufacture and in the foundry; ferro-alloys; electrolytic iron; electric welding and heat treatment; and electromagnetic treatment of ores.

Moissan, Henri—Electric Furnace; translated by Victor Lenher. Ed. 2. 313 pages. 1920. Chemical Publishing Co., Easton, Pa.

"This is a second edition of the translation of the author's *Le Four Electrique*, Paris, 1897, the first edition having appeared in 1904. No attempt has been made to add in any way to the text of the original French edition."—*American Journal of Science*, April, 1921, p. 367.

Pring, J. N.—The Electric Furnace. 485 pages. 1921. Longmans, Green & Co., New York. \$10.50.

Fairly technical work covering general field, but devoting some 200 pages to production of iron, steel, and ferro-alloys, and consideration of furnace refractories.

Foundry Practice.

The American Foundrymen's Association, co-operating with the National Research Council, has published in mimeograph form a bibliography of 82 pages on "Refractories Used in Foundries" (October, 1921), and one of 66 pages on "Natural and Synthetic Foundry Sands and Clays and Employment of Greater Proportions of Used Sand in Molding and Core-Making Operations" (September, 1921).

Carman, Edwin S.—Foundry Moulding Machines and Pattern Equipment. Ed. 2. 225 pages. 1920. Penton Publishing Co., Cleveland. \$5.

Excellent practical guide to the use of various types of molding machines, and the pattern and flask equipment necessary for their use. Of value to everyone interested in foundry practice.

Duponchelle, J.—Comment on pratique la fonderie. 500 pages. Dunod & Pinat, Paris. 52 francs.

Reviewed in *La Fonderie Moderne*, April, 1921, p. 86.

Farrell-Cheek Steel Foundry Company—Illustrated Story of a Farrell-Cheek Steel Casting. 41 pages. 1921. The Company, Sandusky, Ohio.

Irresberger, Carl—Die Formstoffe der Eisen- und Stahlgießerei; ihr Wesen, ihre Pruefung und Aufbereitung. 245 pages. 1920. Julius Springer, Berlin. 24 marks.

McCracken, Edward M. and Sampson, C. H.—Pat-

tern-Making. 111 pages. 1921. D. Van Nostrand Co., New York. \$2.

Manuel complet du fondeur en fer et en cuivre. New ed. 2 vols. L. Mulo, Paris. 9 francs, unbound.

Osann, Bernhard—Lehrbuch der Eisen- und Stahlgießerei. Revised and enlarged. 1920. W. Engelmann, Leipsic.

Reviewed in *Feuerungstechnik*, March 15, 1921, p. 110.

Pitt, George J.—*Iron Foundry Practice*. 1921? Cassell & Co., London. 6 sh. net.

Author is instructor in iron founding, Sydney Technical College, New South Wales.

Schott, Ernst A.—Die Metallgiesserei. Ed. 2, revised and enlarged. 397 pages. B. F. Voigt, Leipsic. 37.50 marks.

Reviewed in *Stahl und Eisen*, Oct. 28, 1920, p. 1469.

Schott, Ernst A. and Einkenkel, A.—Giesserei-Materialkunde. 331 pages. 1920. Hermann Meusser, Berlin. 48 marks.

Detailed consideration of foundry practice with ferrous and non-ferrous metals, fuels and foundry accessories; and chemical, physical and metallographic testing.

Shaw, Ben, and Edgar, James—Foundrywork. 115 pages. 1921. Sir Isaac Pitman & Sons, New York. \$1.

Brief, elementary guide to methods in iron and brass foundries. Based on British practice.

Shaw, Ben, and Edgar, James—Patternmaking. 108 pages. 1921. Sir Isaac Pitman & Sons, New York. \$1.

Treiber, E.—Giessereimaschinen. 1920. Gruyter & Co., Berlin. 2.10 marks.

Fuel and Refractories.

Frion—Le chauffage au charbon pulverisé. 32 pages. 1921. Chaleur & Industrie, Paris.

Larcheveque, Marc—Terres refractaires. Ed. 2. 76 pages. n. d. G. & M. Marin, Vierzon, France.

Considerable information about composition and properties of refractory clays and sands. Little attention to applications.

Muenzinger, F.—Kohlenstaubfeuerungen fuer ortsfeste Dampfkessel. 124 pages. 1921. Julius Springer, Berlin. 24 marks.

Refractories Manufacturers Association—Brands of Fire Brick and Other Refractories. Ed. 3. 40 pages. 1921. (Frederic W. Donahoe, 840 Oliver Building, Pittsburgh.)

An alphabetical list of brand and trade names with the manufacturer of each, and an alphabetical list of manufacturers with the brands manufactured.

Sexton, A. Humboldt—Fuel and Refractory Materials; Revised and Enlarged by W. B. Davidson. 382 pages. 1921? Blackie & Son, London. 12 sh. 6 d. net.

Contains much new matter, the chapter on by-products having been practically rewritten, with considerable attention to low-temperature carbonization.

Heat Treatment.

Brearley, Harry—Case-Hardening of Steel; an Illustrated Exposition of the Changes in Structure and Properties Induced by Cementation and Allied Processes. Ed. 2. 207 pages. 1921. Longmans, Green & Co., New York. \$6.

Valuable practical work.

Brearley, Harry—Le traitement thermique des aciers a outils; translated by Navant. Libraire Loubat & Cie, Paris.

Colvin, Fred H. and Juthe, K. A.—The Working of

Steel; Annealing, Heat Treating and Hardening of Carbon and Alloy Steel. 245 pages. 1921. McGraw-Hill Book Co., New York. \$3.

Authors are, respectively, editor of *American Machinist*, and Chief Engineer of American Metallurgical Corporation. Well written.

Driver-Harris Company—Case Carbonizing. 111 pages. 1920. The Company, Harrison, N. J.

Discusses, also, cyanide hardening, gas hardening, lead tempering, and the properties and uses of "Nichrome."

England—Research Department—Heat Treatment of Carbon Gun Steels. 1920. (Report No. 48.) H. M. Stationery Office, London. 6 sh. 8 d. postpaid.

England—Research Department—Heat Treatment of Nickel Gun Steel. 1921. (Report No. 49.) H. M. Stationery Office, London. 3 sh. 7½ d. postpaid.

Supplementary to Report No. 9, which had reference to time and temperature of tempering. Present report deals chiefly with microstructure as related to heat treatment, and effect of various rates of cooling through the critical range.

Giolitti, Federico—Heat Treatment of Soft and Medium Steels; Theory and Practice of the Preliminary Heat Treatments to Give Maximum Toughness to Steels Used for Machine Parts; translated by E. E. Thum and D. G. Vernaci. 374 pages. 1921. McGraw-Hill Book Company, New York.

Much hitherto unpublished information.

Guillet, L.—La trempe et le revenu des produits métallurgiques. 264 pages. 1921. Octave-Doin et Fils, Paris. 6 francs.

Reviewed in *La Nature*, April 23, 1921, sup. 6. 136.

Millett, Kenneth B.—Cooling of Quenching Oil in the Heat Treatment of Steel. 29 pages. 1921. Griscom-Russell Co., New York.

Discusses various quenching mediums and describes Griscom-Russell cooling equipment.

Hygiene.

Brundage, Dean K.—Diseases Prevalent Among Steel Workers in a Pennsylvania City. 14 pages. 1921. Government Printing Office, Washington, D. C. (Public health reports. Reprint 632.)

Forms pages 3163-3171 of report for December 31, 1920.

England—Industrial Fatigue Research Board—Fatigue and Efficiency in the Iron and Steel Industry; Summary of Contents of Report No. 5 of the Industrial Fatigue Research Board. 1921? H. M. Stationery Office, London. 3 sh.

Based on investigations of numerous iron and steel works in England, Scotland and Wales. As a result of reduction from 12-hour to 8-hour shifts open hearth production increased two to nine per cent, but there was no change in output of blast furnaces and rolling mills.

UNITED STATES BUREAU OF STANDARDS PUBLICATIONS.

Certain 1920-21 publications of the United States Bureau of Standards likely to interest chemists and metallurgists in the steel industry are grouped together below for economy of space. They may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Circulars.

No. 26—Analyzed Iron and Manganese Ores; Methods of Analysis. Ed. 4. 20 pages. 1921. 5 cents.

No. 42—Metallographic Testing. Ed. 2. 11 pages. 1921. 5 cents.

Scientific Papers.

No. 376—Chemical Ranges of Some Commercial Nickel Steels, by Howard Scott. 195-214 pages. 1920. 5 cents.

No. 395—Relation of the High-Temperature Treatment of High-Speed Steel to Secondary Hardening and Red Hardness, by Howard Scott. 521-536 pages. 1920. 10 cents.

No. 396—Thermal and Physical Changes Accompanying the Heating of Hardened Carbon Steels, by Howard Scott and H. Gretchen Movius. 537-556 pages. 1920. 5 cents.

No. 397—A Study of the Relation Between the Brinell Hardness and the Grain Size of Annealed Carbon Steels, by Henry S. Rawdon and Emilio Jimeno-Gil. 557-593 pages. 1920. 10 cents.

No. 402—Use of Ammonium Persulphate for Revealing the Macrostructure of Iron and Steel, by Henry S. Rawdon. 715-723 pages. 1920. 5 cents.

No. 404—Magnetic Reluctivity Relationship as Related to Certain Structures of a Eutectoid-Carbon Steel, by C. Nusbaum, W. L. Cheney and H. Scott. 739-757 pages. 1920. 5 cents.

No. 408—Effect of the Rate of Cooling on the Magnetic and Other Properties of an Annealed Eutectoid Carbon Steel, by C. Nusbaum and W. L. Cheney. 65-78 pages. 1921. 5 cents.

Technologic Papers.

No. 165—Enamels for Sheet Iron and Steel, by J. B. Shaw. 88 pages. 1920. 5 cents.

No. 72—Cast Iron for Locomotive Cylinder Parts, by C. H. Strand. 25 pages. 1920. 10 cents.

No. 178—Steel Rails from Sink-Head and Ordinary Rail Ingots, by George K. Burgess. 61 pages. 1921. 20 cents.

No. 179—Electric-Arc Welding of Steel: 1. Properties of the Arc-Fused Metal, by H. S. Rawdon, E. C. Grossbeck and L. Jordan. 63 pages. 1921. 15 cents.

Chronological bibliography, 52 references.

No. 191—Some Factors Affecting the Life of Machine-Gun Barrels, by W. W. Sveshnikoff. 27 pages. 10 cents.

No. 192—Tests of Centrifugally Cast Steel, by George K. Burgess. 22 pages. 1921. 10 cents.

CAMDEN IRON WORKS SOLD.

The Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., has purchased from the receivers of the Camden Iron Works, Camden, N. J., all patent rights, patterns, etc., used in the manufacture of hydraulic tools and high-pressure valves. The Camden Iron Works has sold for many years through R. D. Wood & Co. of Philadelphia and others. The purchase of the Birdsboro Steel Foundry & Machine Co. includes the machinery, jigs, templets, etc., required for the production of operating valves and all stock which was in process of manufacture at the time of purchase. This deal places the Birdsboro Steel Foundry & Machine Co. in a position to supply hydraulic equipment of every character.

A part of the plant of the Camden Iron Works has been purchased by the U. S. Cast Iron Pipe & Foundry Co., Philadelphia.

Progress in Iron and Steel Metallurgy

General Improvements Shown in the Sintering of Ore, Open Hearth Furnace Construction and in the Treatment of Steel Products—Electric Furnace Standardized.

By J. M. HALL*

TO OPERATORS of blast furnaces perhaps the most interesting developments during the year 1921 are the experiments carried out in Canada on the smelting of Titaniferous iron ores, and the continued progress in the development of the great project for concentrating and sintering the lean iron ores of the East Mesabi district.

Heretofore in the smelting of Titaniferous iron ores the titanium has been considered an acid and lime has been used as in ordinary practice. As titanium is neutral or amphoteric (i. e., its oxide will take the place either of an acid or of a base in a slag), it is possible to use silica instead of lime as a flux for these ores. In the experiments above mentioned this was done, and the results secured are said to have been very encouraging and the slags in every way satisfactory. Should further trials confirm the results of the preliminary experiments, a vast amount of iron ore containing titanium as well as silica will be made available.

As is well known to readers of THE BLAST FURNACE AND STEEL PLANT, the Mesabi Iron Company controls an area of 12 to 15 square miles of territory in the Eastern Mesabi district, in which lies a vast deposit of lean iron ore which is being developed on an enormous scale. These ores are to be crushed, concentrated by magnetic methods and sintered. Already the first unit of the sintering plant has been constructed with a capacity of 1,000 tons of sinter in 24 hours. The ultimate capacity of the plant is to be 30,000 tons of sinter per day. The product is already on the market.

In steel works practice very radical changes are being made in the construction of the ports of open hearth furnaces with a view to increasing the life of the port, speeding up the operation of the furnace and burning by-product coke oven gas more satisfactorily than has been possible heretofore. It is especially noteworthy that after a long period in which very little change has been made in the design of open hearth furnaces radical departures in design should be proposed and successfully tried out by at least two independent inventors.

At the plant of the Brier Hill Steel Company the Egler design has been tried out for producer gas. In this type of furnace, positive pressure by means of a blower is applied to both air and gas. The latter comes up a flue at the extreme end of the furnace in a position corresponding to that of the air flue in the old design. This flue is turned downward to form the port in the usual manner, but the air is brought up a flue placed between the gas flue and the hearth of the furnace in such a manner that the air rises vertically into the gas flue some distance back of the mouth of the port. The gas and air are intimately mixed before leaving the port,

The author is metallurgist for the Taylor-Wharton Iron & Steel Company, High Bridge, New Jersey.

and the flame is introduced into the furnace very much in the manner of the flame of a blow torch. It is said that the port temperatures are not unduly high, and that the roof is protected by a small moving body of air which is furnished by the small excess supplied over that needed for combustion.

In addition to the flues mentioned, there are two auxiliary flues at each end of the furnace leading to the checkers which can be closed at will by means of water cooled mushroom valves. In the end of the furnace where the flame is entering, these flues are closed while those at the discharge end are opened. In this manner the rate of flow of the producers of combustion is decreased at the discharge end of the furnace. A very high hearth temperature and very perfect transmission of the heat to the bath has been secured, and the output of the furnace has been very high. Furnaces have been designed also for burning coke oven gas, natural gas, oil and tar.

The McKune design was first tried out for the burning of by-product coke oven gas in the plant of the Steel Company of Canada. In general the principle adopted is very similar to that of the Egler design inasmuch as both types are designed to slow down the products of combustion at the outgoing end of the furnace.

In the furnace as built there are three vertical flues leading up from the well in front of the checkers. As in the Egler design, two of these flues are closed at the incoming end of the furnace by suitable dampers; the corresponding pair at the outgoing end are left open. The air at the incoming end is introduced under a blower pressure of about 6 ounces and comes up the central flue, which turns over to form the port. The gas is introduced through pipes on each side of the center port at right angles, and is very thoroughly mixed with the air and burns completely in the first 10 feet of the hearth. The results secured are quite as encouraging as those at Brier Hill.

At the South Chicago works of the Steel Corporation, what is called the Venturi line furnace has been developed and tried out, the general design being more or less on the McKune principle. Producer gas is burned and the furnace is under induced fan draft to take care of the waste heat boilers. The port area is decreased by lowering the roof knuckles and moving the wing walls in such a way as to give a restricted opening in two planes. In addition, the mouth of the gas port is moved about three feet back of the point of greatest restriction so that a channel exists where air and gas mix after leaving the mouth of the port proper and before entering the hearth. This design has resulted in improved life of the gas port or block, and in better operation of the furnace.

At the same plant a combination of the McKune and Venturi line designs is being worked out in which water

cooled dampers, one on either side of the gas port, take the place of the knuckles in the side wall in the original Venturi line design. In operation these dampers are lowered into position at the incoming end of the furnace and raised at the outgoing end, giving an area of 13 square feet where the products of combustion leave the hearth. The air is forced in by a fan and as the furnace has waste heat boilers, induced draft is used at the stack end. The results secured in improved operation of the furnace and increased output have been highly encouraging.

In electric furnace work the most striking development of the year has been the successful starting up of the 40-ton Heroult electric furnaces in the government armor plate plant. These furnaces are round with a shell 18 ft. in diameter and 8 ft. high, with 18-in. brick walls. Three electrodes are used which are 24-in. in diameter for amorphous carbon, and 14-in. for graphite which has been tried experimentally. The furnaces take hot metal from two 75 basic open hearth furnaces in which the phosphorous is reduced to about .015 per cent and in the electric furnace the metal is refined and the sulphur brought down to between .008 and .015 per cent. The problems encountered in designing these 40-ton furnaces called for great skill and ingenuity and we are informed confidentially that the next step will be to a much larger furnace and that the 100-ton electric furnace is in sight.

The Electric Furnace Association has been investigating the most desirable voltages for the manufacture of electric steel, and has concluded tentatively that the shorter arc and lower voltages are on the whole more desirable in the manufacture of high grade steel.

The General Electric Company is experimenting with a 2-ton induction furnace of new design in which the primary coils are above the bath instead of on the same level with it, and in which other new features have been introduced. Following the unsatisfactory showing of induction furnaces in this country in the past, the progress of this type will be watched with interest.

In foundry work the building of the Ford plant, which will eventually have a capacity of 2,500 tons of castings a day, is progressing successfully. This is probably the first plant designed to use direct metal from the blast furnaces on a large scale, and already with the four mechanically charged cupolas which have been started the use of direct metal has been a success. The iron from the blast furnaces is brought to the foundry in 75-ton ladle cars whence it is transferred to 20-ton ladles in which the cupola iron and direct metal are mixed. Proportions varying from 40 per cent direct and 60 per cent cupola metal to 60 per cent direct and 40 per cent cupola metal have been successfully used and even in some cases 80 per cent direct metal with 20 per cent cupola iron has been poured. The ratio contemplated, however, for regular work is about 50 per cent direct metal and 50 per cent cupola iron.

The Malleable Iron Association has published a bulletin in which they call attention to the great improvement in the average quality of the tests submitted by their members, especially in the last three and one-half years. During this time the average tensile strength of the test bars has increased from a little under 49,000 pounds per square inch to over 53,000 pounds per square inch, and the elongation in 2-inch from under 10 per cent to nearly 16 per cent. The association feels that this data represents real progress in the improvement of their product of which they may well be proud.

In Germany oil has been successfully used in a cupola

to decrease the consumption of coke. The methods followed were somewhat similar to those of Mr. Stoughton and the results appear to have been similar.

A very interesting article was published during the year describing the operation of four 60-ton basic open hearth furnaces with hot metal melted in two cupolas 6 ft. in diameter inside of the lining and 30 ft. high to the charging door. This practice was tried during repairs to the plant's blast furnace in order to secure a higher output than was possible with cold charges. The two cupolas were in operation on an average of 18 hours out of a possible 24, and supplied the four open hearth furnaces regularly with 50 tons of hot metal each. During the run some 13,000 tons of iron were melted with quite satisfactory results, and the author of the article believes that in some cases such a process would be worth adopting for a plant having open hearth furnaces but no blast furnace.

Although nothing strikingly new has come up in electric heat treatment, the number of furnaces in operation is steadily increasing, and the range of temperatures possible in these furnaces has been extended. Although in many cases the operation is more costly than that of fuel fired furnaces, yet the superior control of temperatures and the comparative freedom from oxidation and scaling makes electric heat treatment extremely desirable for many classes of products.

Lap welded pipe is now being made by a new process in sizes from 24 in. to 96 in. These pipes are made from high grade open hearth steel bent either hot or cold in rolls very much like those used for forming the shells of boilers, and the weld is made a section at a time by heating the lap inside and outside with gas burners and forming the weld with a power hammer. The pipe is then annealed and afterwards straightened, inspected and tested in the usual manner. The thickness of these pipes range from $\frac{1}{4}$ in. to $1\frac{1}{4}$ in. and the product is used in places where cast iron pipe is not strong enough. These smooth pipes are preferable to riveted joint pipe because, owing to the absence of friction a smaller size can be used to carry the same quantity of water.

It is very encouraging to note that in spite of the severe depression in the iron and steel business so much large scale experimentation has been carried out during the year with such encouraging results.

NATIONAL ASSOCIATION OF COST ACCOUNTANTS.

The National Association of Cost Accountants has recently inaugurated a drive for 400 new members by March 1st, 1922. This organization is national in scope and has members in practically every State in the Union in addition to some in Canada, Mexico and Europe.

There are local chapters in most of the principal cities of the United States. These chapters meet monthly to hear various messages by reputable cost authorities on cost and accounting problems. These local chapters are the clearing house where cost data and plans are exchanged by representative cost men and accountants.

Membership is not confined to men alone as there are several women members now in the Association. All men and women interested in cost accounting are invited to investigate the merits of the organization with a view to becoming active members. Mr. S. C. McLeod, 130 West 42nd St., New York City, is the National Secretary and Business Agent.

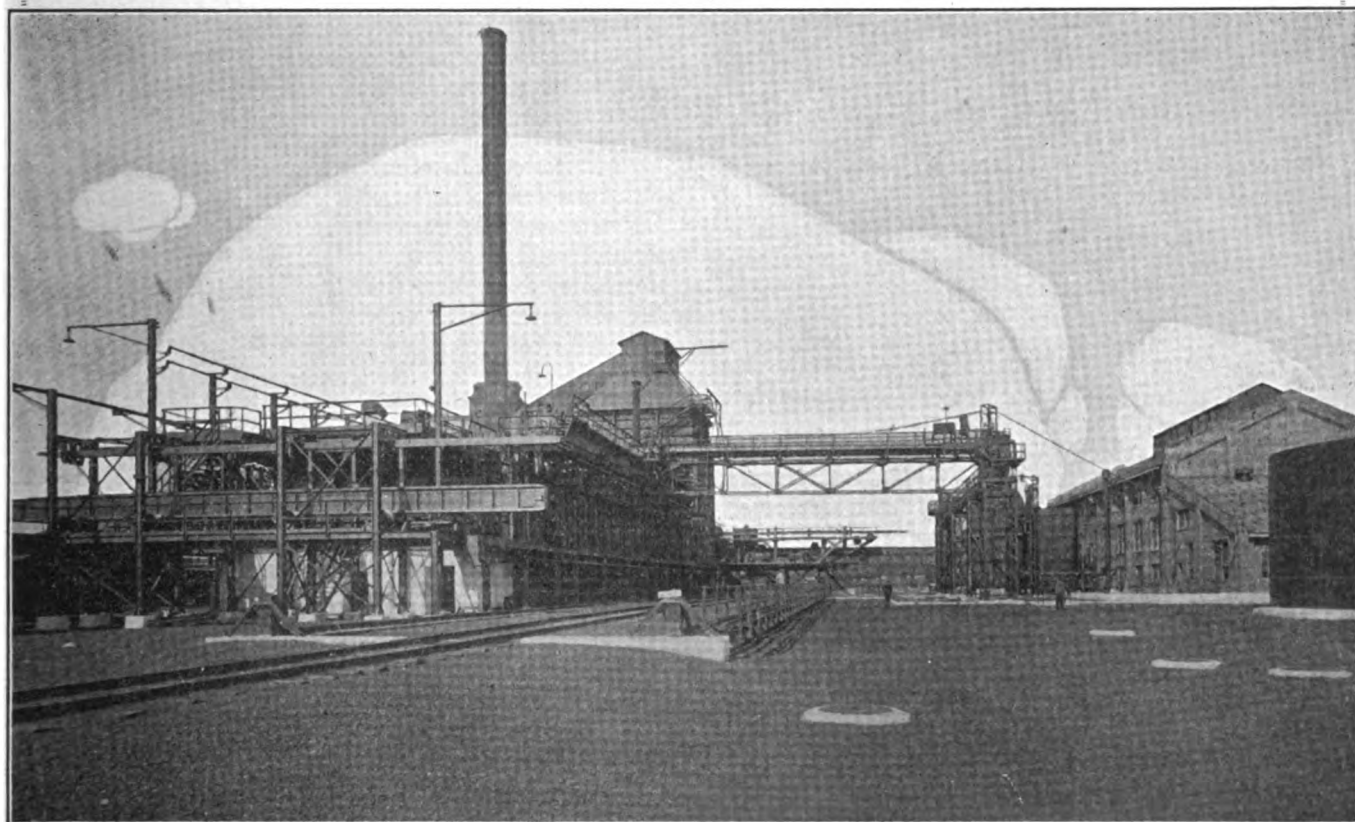
By-Product Coke Oven Department

New By-Product Coke Oven Plants at Johnstown, Pa.
By J. M. HASTINGS, JR.

European By-Product Coking Industry During 1921
By A. THAU

The By-Product Coke Oven Industry 1921
By C. J. RAMSBURG

Recent Development in Steel Mill Cranes
By GORDON FOX



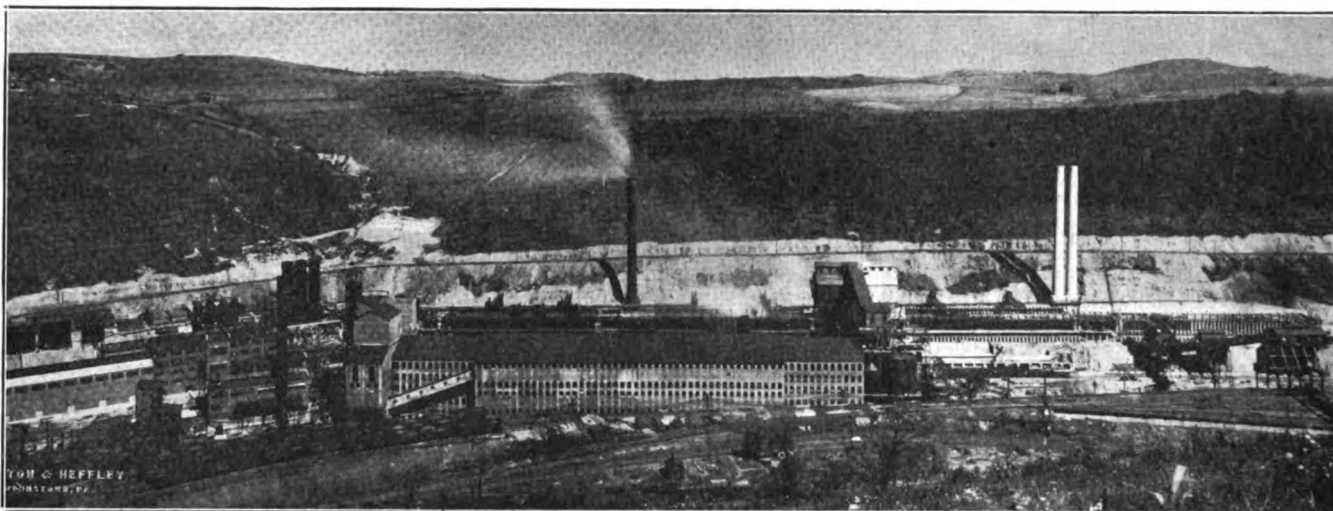


Fig. 1—General view of Rosedale Plant. Left to right: Sulphate storage and by-product building, boiler house, gas washers and coolers, coal preparation, washing and mixing buildings, ovens, coke handling building.

New By-Product Coke Oven Plants

Semet-Solvay Company Completes Fifteen Million Dollar Plants for the Cambria Steel Company at Johnstown, Pa.—The Rosedale and Franklin Plants Described.

By J. M. HASTINGS, JR.*

OCTOBER, 1921, marked the completion by the Semet-Solvay Company of the largest and most difficult by-product coke oven construction contract ever undertaken—largest in view of the actual amounts involved and most difficult on account of the peculiar engineering problems to be solved. This article gives a brief description of the results accomplished during 14 months' work and outlines a few of the difficulties which were successfully overcome.

At Johnstown, Pa., the Cambria Steel Company operates two separate coke oven plants, located about three miles apart, the Rosedale plant supplying coke to the six Cambria furnaces, and the Franklin plant supplying the five Franklin furnaces. The construction work undertaken at Rosedale included the entire by-product coking process from the delivery of coal at the mine head shaft to the production of coke and by-products. At Franklin the new construction began at the point where the gas left the ovens and included complete by-product recovery equipment with the necessary auxiliaries. All the work on both plants was performed by the Semet-Solvay Company. Since the plants are entirely separate, the description is divided into two parts, Rosedale and Franklin.

Rosedale Plant.

Before starting the new work, there was in operation at Rosedale one block of Cambria type ovens with partial by-product recovery, the coal for which was received from the Franklin washery, three miles away.

To eliminate this expensive coal haul, the Semet-

Solvay Company erected a mine head shaft in the center of the Hinckston Run Valley, immediately below the oven batteries, tapping Rosedale Mines Nos. 5 and 6. This shaft is 405 feet overall from the mine gallery, 232 feet below ground, to the top of the hoist. A double skip hoist, each skip of eight tons capacity, operated by a 1,000-hp. motor driven, conical drum hoisting engine, provides a coal handling capacity of 6,000 gross tons per 10-hour day. Since the capacity of the present plant is 3,500 gross tons per day, an ample coal supply is thus assured.

This Rosedale coal from the Cement and Miller seams of the Kittanning veins is a low volatile coal with an average analysis about as follows:

Volatile	18.00 to 18.75%
Fixed carbon	70.0 to 72.0
Ash	10.0 to 11.5
Sulphur	2.1 to 2.4

To secure the desired quality of coke, high volatile coal must be mixed with this, the arrangements for which will be described later. Also the coal must be washed to reduce the sulphur and ash content. Accordingly from the head shaft skip, the coal passes through two 12x17-ft. Bradford breakers and by a 3-in. belt conveyor into the washery building. As it leaves the breakers, if desired, a part of the coal can be sent to a 250-ton loading-bin for use at the boilers or elsewhere.

The washery building is 564 feet long by 99 feet wide and contains 72 Campbell washing tables and 10 draining pits, each of 1,550 tons capacity. These 10 pits are served by two reclaiming bridges equipped with continuous bucket diggers which deliver the washed coal to a

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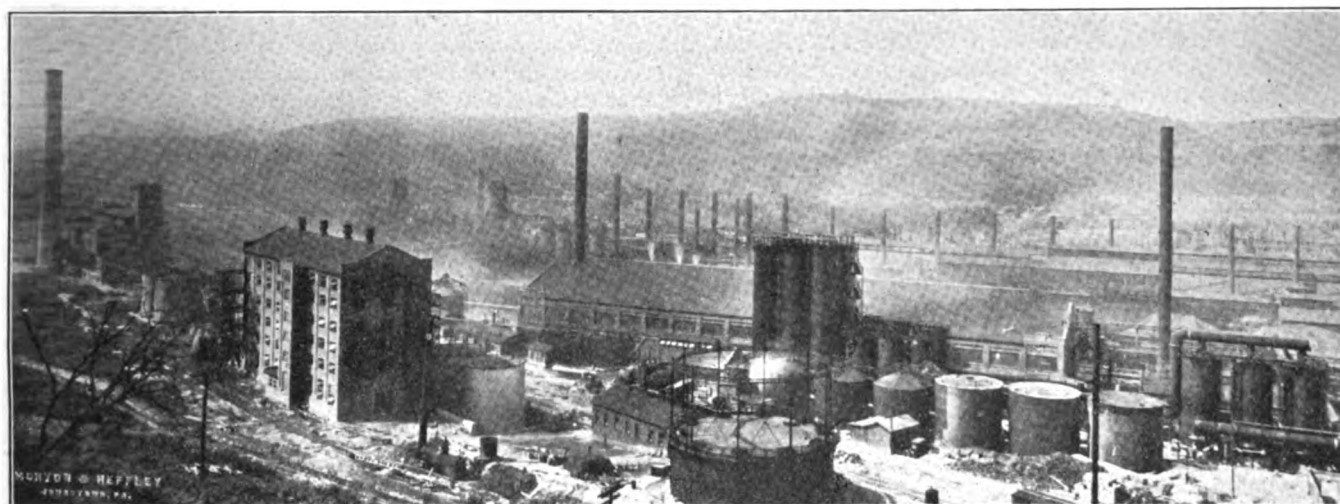


Fig. 2—General view of Franklin Plant. Left to right: Boiler house, benzol plant, by-product building, gas washing and cooling apparatus.

36-in. belt conveyor which in turn delivers to the mixing plant. Refuse from the washing tables falls into collector bins and thence into railroad cars.

This coal washing plant is the largest of its type ever built and has a capacity of 4,000 gross tons per 10-hour day. About 20 per cent of the ash and 50 per cent of the sulphur in the coal are removed by the washing process and the draining pits are so designed that the coal recovered contains only from 6 to 8 per cent moisture.

In the coal mixing plant, located at the eastern end of the washery building, a 250-ton bin is provided for the washed coal and a 1,000-ton circular bin for high volatile coal. This coal is received from cars at a track hopper, sent through a Bradford breaker and a double roll crusher and delivered by elevator to this circular bin. From these two bins, the high volatile and low volatile coals are delivered by short proportioning feeders into two spiral moving conveyors where intimate mixture is secured, it being possible to vary the mixture to contain from 20 per cent to 80 per cent high volatile coal. The mixed coal is then elevated by two belt bucket elevators, each of 200 tons per hour capacity, to two conveyor belts which deliver into the 3,000-ton coal bunker above the ovens.

The above described equipment provides a complete modern coal handling and washing plant which will supply the entire coal requirements of the ovens at a minimum expense.

Ovens.

As now completed there are four blocks with a total of 208 ovens at the Rosedale plant, having a total capacity of 3,500 gross tons of coal per day. Of this total, the 128 Cambria type ovens will take about 1,700 gross tons and the 88 Semet-Solvay ovens about 1,800 gross tons. All the ovens are of the modern regenerator type.

From these 3,500 tons of coal charged per day, products will be obtained approximately as follows:

Furnace coke	2,695 gr. tons
Domestic coke	40 gr. tons
Breeze	65 gr. tons
Sulphate of Ammonia...	104,000 lbs.
Light oil	12,000 gal.
Tar	32,000 gal.
Surplus gas	25,000,000 cu. ft.

Coke Handling.

Three 40-foot coke quenching cars operated by compressed air, each attached to a 27-ton electric locomotive, receive the coke as it is pushed from the ovens and proceed to one of the two brick quenching stations. The quenching operation requires about 55 seconds per oven. The quenched coke is dumped on a 200-foot inclined dock equipped with a rotary feeder at the foot, which delivers on to a 42-in. belt leading to the screening station.

At this point the oversize material is first removed by passing the coke over a rotary grizzly screen with 4-in. spaces. This oversize coke is crushed and delivered with the rest to a second rotary grizzly with $\frac{3}{4}$ -in. spaces. All coke passing over this screen is conveyed by belt 250 feet across the valley to the furnace loading station and distributed by a shuttle conveyor to a specially designed 250-ton inclined bin which prevents breakage when the coke is loaded into cars.

The undersize coke passes to a domestic screen of the shaking type where the coke over $\frac{1}{2}$ -in. is separated for domestic use and the breeze is delivered to cars and returned to the plant boiler house.

By-Product Equipment.

Leaving the four blocks of ovens the gas enters a 78-in. common foul gas main leading to the primary coolers of which four are provided, each 10 feet in diameter by 45 feet high, arranged in parallel. These are of the well-known Semet-Solvay grid type in which the cooling is effectively performed by direct contact between the gas and a circulating liquor sprayed in at the top. This liquor is cooled after each contact with the gas by passage through 120 stacks of 2-in. cooling coils, each 30 pipes high, over which water is running. These gas coolers serve not only to cool the gas but also to condense and separate out practically all the tar and naphthalene.

It is interesting to note that due to the difference in rate of heat transfer through metals from water to water and from gas to water, the efficiency of the Semet-Solvay coolers is approximately 50 times that of the old type of tubular coolers. It is also of interest to note the well demonstrated facts that under normal operation these grid type coolers never require cleaning and that during the entire life of the plant there are no repair costs other than occasional renewals of spray nozzles.

From this point the gas enters four Roots exhausters,

each of 83.4 cu. ft. capacity per revolution, two being driven by 300-hp. motors and two by 15x22-in. Ridge-way engines. From the exhausters the gas passes through three 22,000,000-ft. capacity P. & A. tar extractors which remove the last traces of tar, and enters the three ammonia saturators. Here the gas comes in contact with a 5 per cent solution of sulphuric acid which absorbs as sulphate all the ammonia present.

Three final coolers in series, of the same design as the primary coolers, are next in line; there the gas is further cooled to about 20 deg. C. before entering the light oil scrubbers. The water circulated over the grids of these final coolers runs to a sump where any small amount of naphthalene remaining in the gas is brought

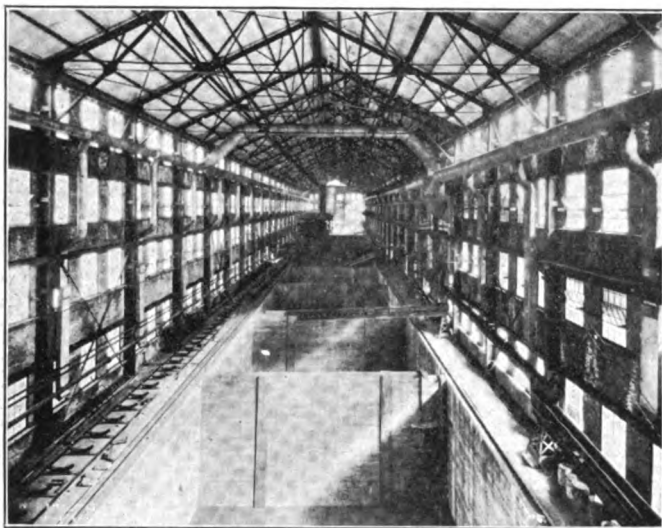


Fig. 3—Interior of coal washery.

down and collected and the water is pumped under 200-ft. head to a spray pond located 110 feet above on the hill side. From this pond the water returns by gravity to the tops of the final coolers. Tests on this spray pond have shown an actual cooling on favorable days to 3 deg. C. below the atmospheric temperature.

The three light oil scrubbers are 16 feet in diameter and 90 feet high, filled with wooden grids similar to those in the coolers. A heavy petroleum absorbing oil is used to remove the light oils from the gas, the saturated oil being pumped to the light oil building.

The gas is now clean and ready for distribution. From 30 per cent to 35 per cent of the total is returned to the ovens for fuel gas and the remaining 65 to 70 per cent is pumped to the steel mills by two 150 cu. ft. Connersville exhausters, each driven by a 425-hp. twin Ball engine.

This surplus gas, estimated at 25 million feet per day, will replace in the mills approximately

500 tons of coal or
100,000 gallons fuel oil or
13,000,000 feet of natural gas or
100,000,000 feet of producer gas.

Ammonia Recovery.

Ammonia recovery in the Semet-Solvay system begins with the liquor circulation maintained on the collector or hydraulic main. By the use of numerous sprays at this point the gas is cooled to about 76 deg. C., relieving somewhat the load on the primary coolers, preventing effectively the formation of pitch deposits in the main

and removing from the gas the fixed ammonia salts. Since the overflow from the primary cooler system is returned to the hydraulic main circulation, it is evident that the overflow from this latter circulation system will contain all the fixed ammonia, but very little free ammonia. This means a minimum volume of weak liquor requiring distillation and resultant low costs of ammonia recovery when sulphate is the desired product.

At the Rosedale plant one Semet-Solvay 6-ft. ammonia tank still has been provided which will handle readily all the weak liquor produced. The ammonia gas from this still enters the saturators with the oven gas for absorption as sulphate. At the Franklin plant a con-

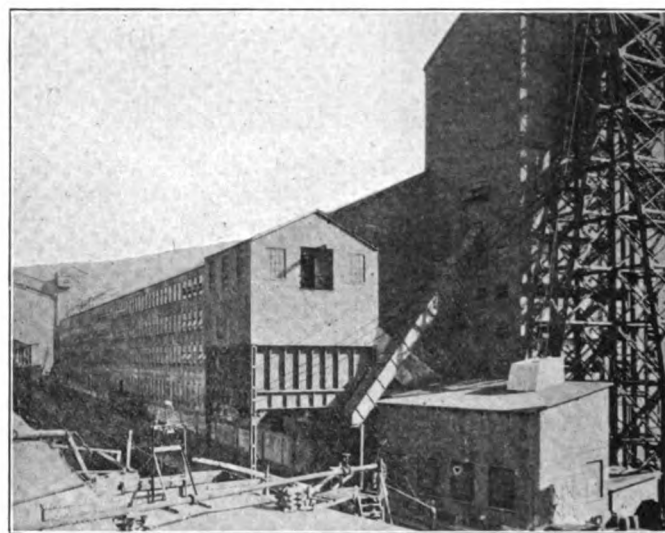


Fig. 4—Coal washery, Rosedale plant. Mine head shaft on right.

denser has been installed in connection with the ammonia stills to permit the production of concentrated liquor if desired.

From the saturators, the crystallized sulphate of ammonia is delivered continuously by air ejectors to centrifugal dryers, of which nine are installed, three for each saturator, where it is dried and washed free of acid. From the dryers, a belt conveyor delivers the salt to the sulphate storage building, 176 feet long by 56 feet wide, where 4,000 tons can be stored. The salt can either be loaded out in bulk in cars or bagged as desired.

Light Oil Recovery.

From the light oil scrubbers, the absorbing oil carrying the light oils is pumped through a heat exchanger and a preheater into three Semet-Solvay stripping stills, which provide ample spare capacity. These are continuous stills, 6 feet in diameter, each with a capacity of 20,000 gallons per hour, in which the light oil is distilled off the absorbing oil, the former being condensed and the latter cooled and returned to the scrubbers. The Semet-Solvay system is notable for its high heat efficiency and for the fact that the separation of light oil and absorbing oil is so complete that no intermediate redistillation of the light oil is required before it is worked up into motor fuel or pure benzol, toluol and solvent. The absorbing oil is also thoroughly cleaned and washed in the process so that revivifying is never necessary.

From the Rosedale light oil plant, the light oil produced is shipped to the benzol plant at Franklin.

Auxiliary Equipment.

The new boiler house at Rosedale contains three 768-

hp. B. & W. boilers each equipped with a Coxie stoker for burning breeze. The plant is provided with track hopper, elevator and fuel bins for breeze or coal handling and a traveling bucket and skip hoist for removing ashes.

Two Bury air compressors have been installed, each directly connected to a 225-hp. motor. These have a combined capacity of 2,000 cu. ft. of free air per minute to supply the various needs of the plant.

In the transformer building are two 500-kw. 250-volt d.c. motor generator sets and one 500-kw. 275-volt syn-

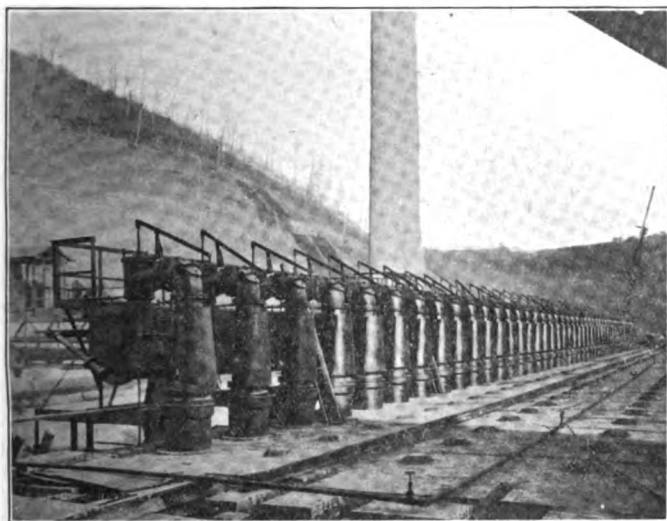


Fig. 5—Semet-Solvay ovens. Top of B1-3. Rosedale Plant.

chronous converter for supplying the direct current required in the plant. High tension a.c. current from the steel plant power house is transformed for the coke oven plant by three 1,000-k.v.a. transformers.

Modern locker and toilet facilities are provided in the several buildings for the use of the men employed at those points. Throughout the plant every care has been taken to render the working conditions as safe and attractive to the men as possible.

Franklin Plant.

The old Franklin coke oven plant consisted of 11 batteries of ovens of various types, including one of the first blocks built in this country, with a total of 492 ovens having a capacity of 4,500 gross tons of coal per day. Partial recovery of by-products was undertaken in old type apparatus.

As the plant now stands no changes have been made to the ovens proper, but beginning at the points where gas leaves the oven chambers, the Semet-Solvay Company has installed complete modern by-product recovery apparatus which handles the entire gas output of the plant, including hydraulic main circulation systems, gas washing and condensing, tar, sulphate of ammonia, light oil and surplus gas recovery and benzol plant, boiler house and all necessary auxiliary equipment.

By-Product Equipment.

Leaving the ovens, the foul gas from five blocks enters one main and that from the remaining six blocks enters another, which combine in a single 60-in. main at the three primary coolers. These are of the Semet-Solvay grid type similar to those at Rosedale but somewhat larger, being 16 feet in diameter by 45 feet high. Each cooler has a capacity of 60,000,000 cu. ft. of gas

per day. One hundred and sixty banks of cooling coils, each 30 pipes high, serve to cool the circulating liquor.

From the primary coolers, the gas enters the by-product building. This building, of steel and brick construction, as are all the other buildings, is 360 feet long by 83 feet wide. In this building are located the four DeLaval turbo exhausters, each of 14,000 cu. ft. per minute capacity, five P. & A. tar extractors and five Semet-Solvay saturators for ammonia recovery. The gas passes through these sets of apparatus in the order

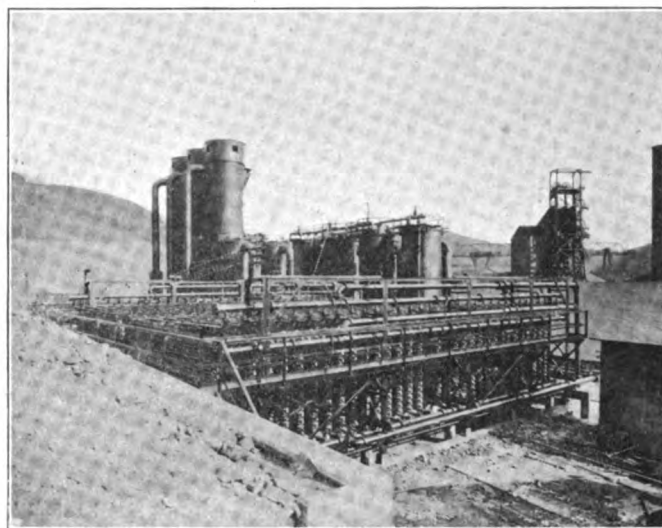


Fig. 6—Gas cooling and washing towers. Rosedale Plant. Cooling coils in foreground.

given and returns to the six final coolers and six light oil scrubbers outside the building, each in two sets of three in series. These are all 13 feet in diameter, the coolers being 45 feet high and the scrubbers 90 feet high. From this point a 42-in. line carries fuel gas to the boilers to take care of the Sunday gas and a 30-in. line delivers surplus gas to two turbine boosters and thence to the steel plant.

The ovens not being of the generator type, only 28,000,000 feet of surplus gas will be released per day at full operation. This 28,000,000 feet, however, will replace approximately:

570 tons of coal or
120,000 gallons of fuel oil or
15,000,000 feet of natural gas or
120,000,000 feet of producer gas.

It is interesting to note that the total surplus gas from the Rosedale and Franklin plants at full operation will replace daily:

1,070 tons of coal or
220,000 gallons of fuel oil,

which represents a direct saving to the Cambria Steel Company of from \$5,000 to \$10,000 per day.

The Franklin coke oven plant at full operation will produce per day by-products other than gas estimated as follows:

Tar 40,000 gal.
Sulphate of ammonia..... 126,000 lbs.
Light oil 15,000 gal.

Ammonia Recovery.

Ten centrifugal dryers in the by-product building re-

ceive the sulphate precipitated out in the saturators and deliver the dried salt to a belt conveyor running into the storage room where 5,000 tons can be stocked. Available storage space is 160 feet by 83 feet. If desired the two stills provided to free the fixed ammonia and return it to the gas for absorption as sulphate can be used to make crude concentrated ammonia liquor since a condenser has been provided for that purpose.

The flexibility of operation is one of the outstanding features of the Semet-Solvay ammonia recovery system. When sulphate is the desired product, a minimum volume of ammonia liquor requiring distillation is produced, but if for any reason it becomes desirable to make concentrated liquor, the several circulation systems can be readily reversed and, with the addition of small amounts of water, a large proportion of the total ammonia in the gas may be recovered in the form of liquor. The am-

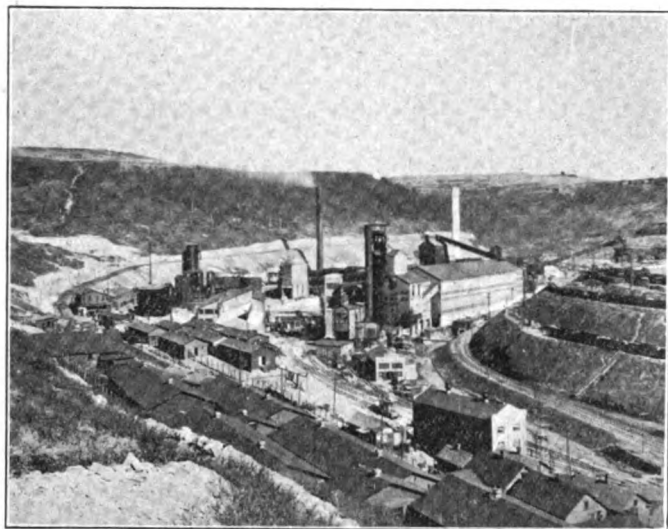


Fig. 7—General view of Rosedale Plant. Bunk houses and light oil building in foreground.

monia recoverable as liquor in this way will vary from 15 per cent to 85 per cent of the total according to the coal used.

To permit this flexibility of operation, it is, of course, necessary that the stills provided have sufficient capacity. In this connection it should be noted that the efficient design of the Semet-Solvay stills insures a capacity of over four times that of any other type of still of equal size.

Light Oil Recovery.

In the benzol plant, four stripping stills are erected similar to those at Rosedale, with the usual equipment of preheaters, heat exchangers and Semet-Solvay system of decanters. Also in this building there are two motor benzol stills with light oil washing equipment and three intermittent stills for the production of pure benzol, toluol and solvent naphtha. In this plant all the light oil produced at Rosedale and Franklin is rectified with daily outputs of approximately:

22,000 gallons motor benzol, or
16,600 gallons pure benzol,
3,700 gallons pure toluol and
1,000 gallons solvent.

This plant is of standard Semet-Solvay design and is complete in every detail including storage tanks for all products and a drum loading station.

Auxiliary Equipment.

The new Franklin boiler house contains five 768-hp. B. & W. boilers, each equipped, as at Rosedale, with a Coxe stoker for burning breeze. These Coxe stokers give a boiler efficiency using breeze, which is comparable with the best results obtained with coal stokers.

A transformer building has been erected which contains three 500-k.v.a. transformers and motor generator equipment of sufficient size to furnish the direct current required in the plant.

The pumps used in the several operations are located in two separate pump houses providing the most satisfactory arrangement to meet local conditions.

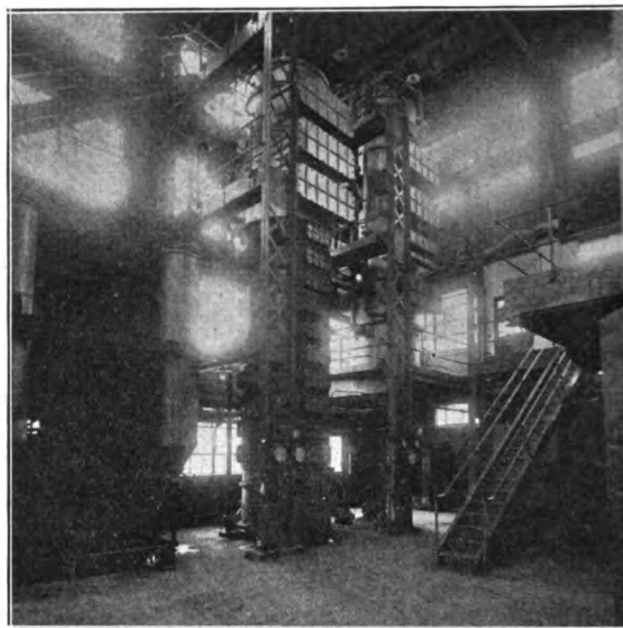


Fig. 8—Interior of by-products building, Franklin Plant, showing ammonia still and condenser.

Adequate locker and toilet facilities are provided throughout the Franklin plant, which, as now completed, represents in its entirety one of the finest examples of a by-product recovery plant to be found in this country.

Construction Features.

At the Franklin plant, aside from the usual troubles encountered in modifying existing equipment without serious interference with the operation, the construction work proceeded in an orderly manner and without undue difficulty. At Rosedale, however, due to local conditions, difficulties were encountered which required great engineering ingenuity to overcome.

Due to the narrowness of Hinckston Run valley it was necessary to construct the Rosedale plant on three distinct levels. On the upper level are the four oven blocks, on the middle level, the by-product buildings and equipment and on the lowest level the coal washery and coal handling equipment. In building these levels a total of over 150,000 cubic yards of excavation was required and 50,000 cubic yards of back fill. Two thousand linear feet of retaining walls were also necessary in which, including the various foundations, a total of 70,000 cubic yards of concrete was poured.

In laying the oven foundations, treacherous conditions were encountered unexpectedly, which made it necessary to sink caissons to solid rock. One hundred and fifty-six of these caissons were put down, six feet in

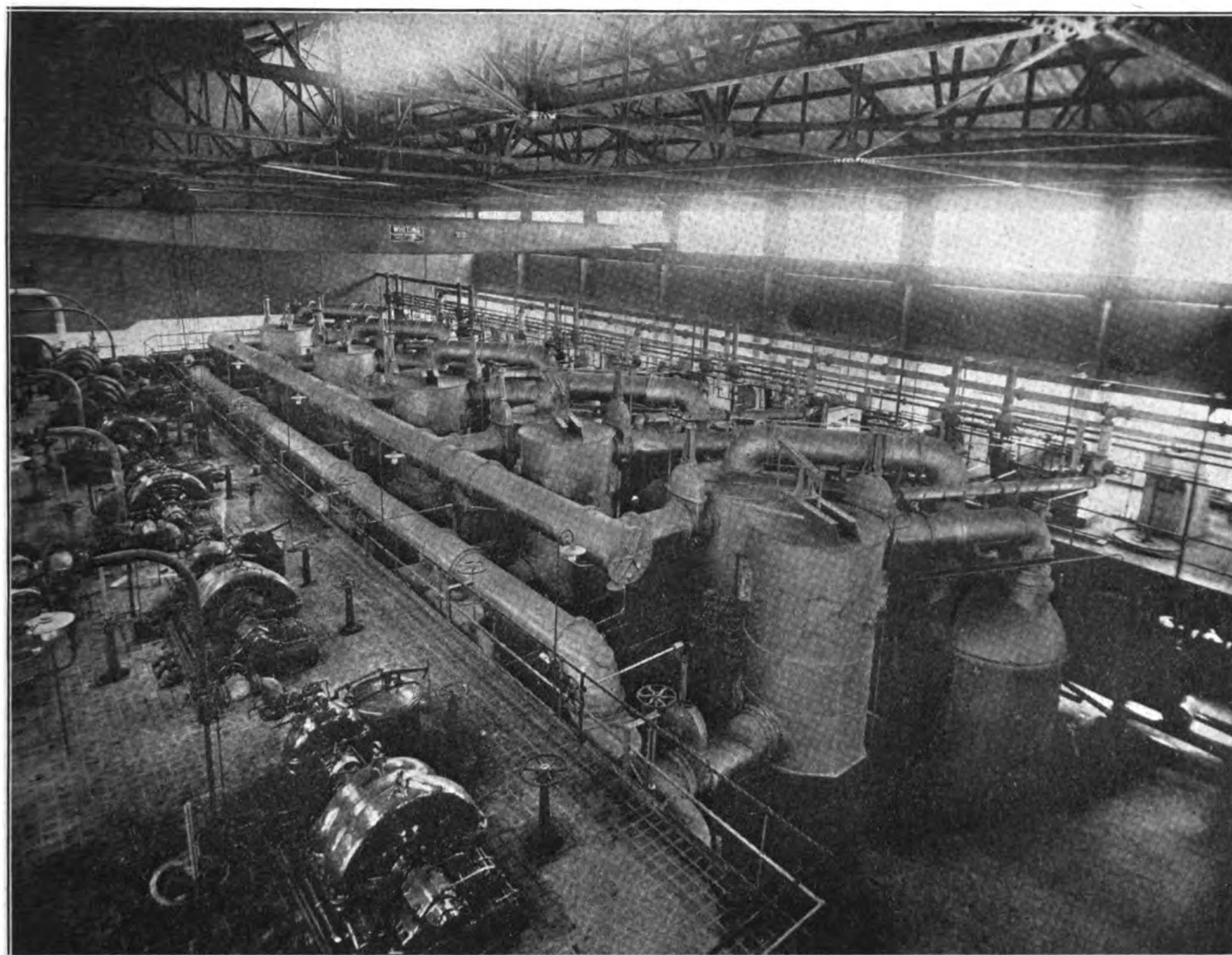


Fig. 9—Interior of by-product building, Franklin Plant, showing, left to right: Exhausters and boosters, tar extractors, acid separators, saturators and centrifugal driers.

diameter and averaging 36 feet deep. The caissons carry a series of 6-ft. square reinforced concrete beams and a concrete slab three feet thick upon which the normal coke oven foundations are erected. By this method the ovens are rendered entirely independent of soil conditions and any possibility of the blocks slipping down hill has been obviated. Several of the caissons run into abandoned mine galleries 30 or 40 feet below ground which caused additional difficulty, particularly in the case of those galleries which happened to contain water. All such difficulties were overcome, however, with entirely satisfactory results.

To provide working space in the center of the valley, it was necessary to construct a 16-ft. concrete culvert to carry Hinckston Run. This culvert is approximately 1,300 feet long, extending through the length of the plant.

In laying the foundations for the by-product building which in itself is built on three levels, particular difficulty was experienced due to the character of the soil at that point. Serious slides were a frequent occurrence, making necessary heavy retaining walls. In the completed by-product equipment, however, every advantage has been taken of the different levels so that gravity flow of liquors has been provided in many instances where ordinarily pumps would be required.

Possibly the greatest problems encountered at both the Rosedale and Franklin plants were those of material handling. There being no level space available at either plant, the storage warehouses were all erected at "Ten Acre," about a mile and a half below Rosedale. At that point, 17 buildings were erected with a total area under cover of 71,850 square feet, including brick sheds, cement sheds, steel and pipe warehouses and complete machine shops where a large part of the assembly details were carried out. All the material for both plants passed through "Ten Acre," about 11,000 carloads having been handled during the period of construction.

As now completed, the Cambria Steel Company possesses at its Rosedale and Franklin plants two of the most modern by-product coke oven plants to be found in the United States and the excellent results obtained in the first weeks of operation have already justified the heavy expenditure incurred. Mr. H. M. Crossett is general superintendent of both plants for the Cambria Steel Company, with Mr. J. W. McLaughlin as assistant in charge at Rosedale and Mr. E. Merrill as assistant in charge at Franklin. The construction work on both plants was directly under Mr. A. T. Leavitt, chief engineer for the Semet-Solvay Company, Mr. W. T. Snively and Mr. R. A. Foley being resident engineers in charge.

European By-Product Coking During 1921

The Year 1921 Has Been One of Great Anxiety and Depression as Far as the Coking Industry of Europe Is Concerned—No Startling Developments of a Technical Nature Are Reported.

By A. THAU
Coke Works Superintendent, Oxelösund in Sweden

IN ENGLAND hardly a single plant has operated up to its capacity and few companies had any or sufficient stocks of coal on hand to keep the ovens even warm enough to maintain an ignition temperature over the period of the coal strike. The most unfavorable conditions in the pig iron trade reflected further upon the coking industry and a large number of coking plants have been idle throughout the year, while the majority kept going with a reduced output.

The use of coke oven gas for domestic purposes has received a further serious setback owing to these conditions. There are comparatively few towns in England drawing gas from adjacent coking plants, the principal town depending upon coke ovens for its gas supply being Middlesborough. Pontypridd in South Wales also made arrangements to draw the greater part of its gas from the Maritime Coke Works, which are located nearby. This plant was enlarged for this purpose, but owing to the lack of coke orders the additional part of the plant could not be started and the gas works which deferred an enlargement of plant in the expectation of being supplied with coke oven gas are now in a precarious position.

The introduction of coke oven gas for domestic use has been greatly hampered in England because the coke oven owners were unable to give the necessary guarantees for an uninterrupted continuity of supply in case of strike or lack of coke trade. The municipal gas authorities maintain that, if they are compelled to keep up their gas plant at full capacity size and in good order solely for emergency, and in addition to this must keep huge stocks of coal on hand which naturally deteriorate or begin to burn, they might just as well keep the gas works going and do without the coke oven gas altogether. As long as this state of affairs exists, there is little hope for a more extensive use of coke oven gas for domestic purposes. The only gas works in England operating by-product coke ovens, viz., the City of Birmingham, has, owing to difficulties in disposing of the metallurgical coke, been compelled to discontinue the operation of the coke ovens during the latter part of the year. At the same time the sales of gas in Birmingham are 50,000,000 cubic feet per week lower, compared with the corresponding period of 1920.

Even though those batteries which were operated at all could not be worked to their full capacity, it is surprising to note that there are still a number of beehive oven plants in operation. It would be wrong to conclude that the old superstition of superiority of beehive coke compared with by-product coke is responsible for this, but it can be safely assumed that those collieries still operating beehive ovens are depending upon their waste heat as a source of steam supply for their antiquated surface plant.

In view of the feared competition from the rapidly developing synthetic nitrate plants on the European Continent, great efforts are made to maintain a strong hold of the world's sulphate markets. The English sulphate of ammonia federation is continually urging its members to improve the quality of the sulphate by eliminating the free sulphuric acid which is responsible for the salt forming hard lumps and injuring the bags, while a sulphate with a given content of moisture is naturally correspondingly higher in nitrogen if by the absence of free acid a neutrality is procured. The English patent literature is full of inventions as to means for obtaining a neutral sulphate and a great number of supplementary plants have been erected recently with this end in view. The most simple and effective arrangement is to spray the sulphate immediately upon leaving the saturator with water diffused like a fog so that the moisture envelopes every crystal. Other inventors apply ammonia vapor from the still for operating the salt ejector. Others apply ammonia to the sulphate while being whizzed in the centrifugal dryer. Raw ammonia liquor, owing to its contents of pyridine and naphthalene impurities, is not suitable for the purpose and discolors the sulphate. Another type of plant operates with two saturators in series, in the first one the salt drawn from the second is neutralized and the excess of ammonia escaping from the first saturator is fixed by the acid of the second. Finally it has been decided to leave the manufacturing process as it is and treat the sulphate afterwards with a proportionate addition of powdery slaked lime in a rotating kiln heated by gas, passing the escaping vapors through a seal of sulphuric acid to prevent a loss of ammonia. All these processes are being experimented with more or less on a trial basis and their great variety tends to conclude that no proper judgment as to the superiority of the one or the other can be passed until more uniform means of tackling the problem have come to stay.

While comparatively few English coking plants were formerly equipped to recover the benzol from the coke oven gas, the necessities of the war made the rapid addition of benzol recovery plant to all by-product works compulsory and it was surprising to note how quickly and successfully the chemical engineer of England adapted themselves to the new task because the few pre-war plants in existence were almost exclusively of German origin. The rapid erection of so many benzol plants was accompanied by the repeated question, "What are we to do with all those benzol products after the war when the army and navy cease to be our main customers?" Three years of peace have shown that such fears were not justified and that the demand by far exceeds the production and would still do so even though all plants were working to full capacity. The

National Benzol Association, strongly supported by the English automobile associations, is endeavoring to make the recovery of benzol from coal gas compulsory by law even on gas works above a certain capacity.

The trial by Bury at the Skinningrove Iron Works, published immediately after the war, to recover the ethylene from the coke oven gas in form of alcohol in absorbing the ethylene in 6 deg. Be. sulphuric acid have not been realized on a commercial scale, although great expectations were expressed in responsible quarters. The heat economy of the process is so unsatisfactory that almost as many heat units must be spent as are recovered in the form of alcohol.

Low temperature carbonization, in spite of the formidable antagonism on the side of the gas works and coke oven engineers, has been stronger promoted and recommended than ever before, and the automobile associations who expect a plentiful motor fuel supply at moderate prices from this source, are backing the supporters with all their power. Still as long as the semi-coke is not taken up industrially or as a household fuel on an extensive scale, there is little hope of the plants getting much further than beyond their trial basis where they have been for practically 20 years now. As already expressed in these columns by the writer, low temperature carbonization will as an isolated industry never develop much further; its expansion on a broad scale can only be expected if the iron and steel industry can see its way clear to adopt it as a supplementary side line such as coking plants.

Owing to the unsatisfactory trade of the industry in general, building operations on coking plants cannot be recorded. The few small additions to existing plants are hardly worth mentioning. Extensive repairs are being carried out on the idle plants so as to put them in a good state for restarting.

Germany.

The last year has been a conspicuous one for an overhauling of the coking plants which, driven to their utmost capacity during the war, were in great need of repairs. New walls in the ovens are being almost exclusively rebuilt of silica material.

Few contracts for new plants have been placed, which is not surprising owing to the instability of the money and the continuous rapid depreciation of the paper money. It is quite impossible to get a binding quotation for large contracts and while a coking plant could be built before the war completely for a price approaching something like 8,000 marks per oven, this figure has since increased to 1,000,000 marks and the costs of even a moderate sized plant is in most cases quite out of proportion to the share capital of the company. The latter, however, is with most companies altogether out of proportion to the present money value and the value of the assets.

The German coking industry as a whole is in a singular condition in that most of the Rhenish-Westfalian plants are tied to the huge distribution center supplying an enormous district with domestic gas. The former gas works have been dismantled in these towns and consequently there are no emergency plants in case of the coke works giving out. In addition the peace treaty demands huge quantities of benzol and sulphate which must be delivered to France. On the other hand, the coke trade is slack and has necessarily followed the slump in the iron and steel trade. The result is that, irrespective of a very insignificant coke demand, the ovens must

be kept going at full speed to produce gas, benzol and sulphate and consequently huge stocks of coke can be noticed to be accumulating at almost every coking plant, the coke pile often exceeds in size the adjacent refuse heap of the coal mine.

Before the war labor was very cheap and plentiful in Germany, comparatively, so that its charges did not show very much on the coke prices. The after-war conditions have brought about an entire change in this direction, mainly as a result of the compulsory eight-hour shift. While before the war the coke was treated by hand on a flat bench at a great majority of the plants, great efforts have since been made to introduce mechanical quenching and loading arrangements. In adapting them to existing local conditions, there are different devices on every plant for this purpose. The treatment of the coke by hand on a coke bench is disappearing rapidly now.

On the whole there is no appreciable difference between European and American coking practice except in the fact that as the American by-product coking practice is much younger it is more concentrated in large plants with larger units than in Europe where the plants in the majority are older and scattered about in smaller units. It would, however, be wrong to call them old fashioned or out of date. All new innovations are eagerly tried and if practical are introduced in all plants so as to increase the efficiency and economy of the plants.

The enormous coal supplies which the Versailles treaty extracts from Germany have naturally created an acute scarcity of fuel, and heat economy all around is necessarily the watchword. Skilled engineers have been engaged on every industrial plant and especially on coke works, which are being tested throughout as to their efficiency at repeated intervals and particularly to watch that no recoverable waste heat is allowed to escape unused. The introduction of these heat economists must be held responsible for extensive trials of many new innovations which a few years back were thought impracticable and which, although as yet in their trial state, are bound to come to stay in the next few years. In connection with this must be mentioned first of all the recovery of the incandescent heat of the coke leaving the ovens, which is now not used and destroyed by quenching with water. The cooling of the coke by inert gases not only enables the recovery of the heat, but at the same time improves the physical condition of the coke considerably. As further means to improve the coke must be mentioned the elimination of ash from the coking coal by means of the froth flotation process, tried experimentally also in England by Bury and which was being accomplished at the same time on a commercial scale in Germany.

In the by-product plant innovations must be mentioned as new innovations, the introduction of electrically operated gas governors, though their first appearance dates some years back. They have now been considerably improved and generally introduced. The electrostatic precipitation of tar fog is undergoing extensive trials and the prevention of lime deposits in ammonia stills has been accomplished by a new plant. The absorption of the benzol hydrocarbons by means of a dry solid absorbent, viz., the so-called activated charcoal, is also being investigated on a commercial scale.

Prominent scientists are again eagerly engaged in finding means to utilize the sulphur contained in the coal gas as a binder for the ammonia, thereby eliminating the introduction of the expensive sulphuric acid. After

the processes by Burkheiser and by Feld which many years ago made their appearance and were followed up with the closest interest, and which have not proved workable on a commercial scale, the problem is approached now from every possible direction.

While as yet the great majority by far of the existing coke plants—it will be understood that the last beehive or non-by-product coke oven has disappeared from Germany many years ago—are situated at the coal mines, there is now a great tendency apparent to place new coking plants on the same ground with the iron works in order to be able to utilize the surplus gas from the blast furnaces for heating the coke ovens and having the whole amount of coke oven gas available either for domestic purposes or for the steel plants. The coke ovens act then as heat transformers.

The application of coke ovens to gas works is highly developed on the European Continent. The majority of European capitals are operating coke ovens at their gas works which offer the advantage of being drawn and charged mostly on one shift only. To mention a few, Berlin, Vienna and Budapest are operating Koppers ovens; Munich has adopted the inclined coke oven by Ries; at the Haag are ovens by Klönne and at Kiel the Otto Company has very successfully introduced a battery of new recuperative ovens with vertical flues.

On the newly constructed coking plants in Europe, an extensive and ever increasing use of ferro concrete structures can be conspicuously noticed. Coal hoppers are almost exclusively built of this material as well as the side structures of the ovens for machine tracks. In addition concrete tanks for tar, liquor and oils come more and more into favor wherever a plant is built on ground free from subsidences. Concrete tanks offer the advantage of resisting corrosion much better than iron or steel plates.

Although low temperature carbonization was practically unknown in Germany before the war, it has been taken up as a side line experimentally by the iron and steel industry and several plants on a commercial scale are under erection and will be started early next year, the results of which are awaited with interest.

Belgium.

The Belgian coking industry has soon rallied to pre-war capacity and while little constructional work has been carried out, the plant which was being built in 1914 at Vilvorde (a suburb of Brussels) by the Semet-Solvay Company and stopped by the outbreak of the war has been completed and started early in 1921. It consists of two batteries of 38 regenerator ovens each, from which the gas is taken off in two fractions, of which the first helps to supply the City of Brussels with domestic gas. While the coal mined in Belgium is rather lean for coking, it was formerly mixed with a corresponding amount of English coal high in volatile matter before charging it into the coke ovens. These coals being too expensive now, German coals from the compulsory deliveries of the peace treaty are used in their stead.

France.

While a number of coking plants in France have been destroyed by the war, the total coking capacity has been increased by the acquisition of the Lorraine and Saar districts. These southern coals are as a rule of poor coking quality and must be compressed before charging them as otherwise they will not bind to coke at all. While these industrial centers were under German control, the rather brittle coke was generally mixed with coke from

the Ruhr district which is of much superior quality. The absence of this coke has been keenly felt after the war at the Lorraine and Luxemburg works so that special efforts are being made to improve if possible the coke from the Saar district. New ways to obtain a satisfactory industrial coke from these coals are said to have been discovered by trials, but no details have been published so far. The coking plants in the devastated areas are to be rebuilt together with the mines, but some time will elapse yet before construction can be commenced.

Conclusion.

While this gives an outline of the main coking centers of Europe, a few coking quarters of minor importance have been omitted, particularly the coal field covered by Silesia, Austria, Poland and Czecho-Slovakia have not been mentioned. The political sky in that region has been so much in prominence and so totally clouded everything else during the whole of last year that the conditions of the coking industry remained enveloped for the writer.

A modernly equipped coking plant should be mentioned operating 120 regenerator ovens by Hinselmann at the government mine Emma in Holland and making so excellent a coke that it is not affected by any fluctuations of the coke market.

A single coke oven plant consisting of 60 Koppers regenerator ovens at the Oxelösund's iron works in Sweden operating upon Pocahontas and West Virginia coals from America under the writer's supervision was shut down altogether early in 1921; it being impossible in Sweden to compete against the prices for coke imported from England and pig iron from Luxemburg, owing to the unfavorable rate of exchange.

In summarizing, one can safely assume that after the involuntary impediment in the development of the coking industry on account of the war, new progress is to be expected in the coming year. The new innovations mentioned in this report are also known in the by-product coke industry of America. The froth flotation of coal has been frequently treated in American scientific journals; the cooling of incandescent coke by inert gases has been described by the writer recently in the *Iron Trades Review*. The electrostatic precipitation of tar fog is not sufficiently advanced yet to be able to report practical results. The construction of electrically operated gas governors and of a plant preventing the lime from depositing in ammonia stills will form the subject of two further articles by the writer in these columns.

ACCIDENTS IN THE STEEL INDUSTRY.

The total steel mill accident rate, per 10,000,000 hours worked, has fallen in America 55 per cent since 1907, and the fatal accident rate has fallen more than 70 per cent, as shown by figures of the Department of Labor. The figures given for 1907, per 10,000,000 hours worked, show 7 deaths, 13 cases of permanent disability, 788 cases of temporary disability and a total of 808 cases. For 1920 these figures were 2 deaths, 9 permanent disability, 357 temporary disability and 368 cases in all. Severity rates fell in about the same proportion as frequency rates. Figures for 1907 showed an average of 72 days lost for each 10,000 hours of exposure. In 1920 the loss was only 27 days. All departments, save the electrical, shared in this gain, the open hearth and blast furnace plants showing the greatest decreases, and needing to do so, for their rates in 1907 were more than double the average of the other departments.

By-Product Coke Oven Industry in 1921

The Feature of This Year in the By-Product Coke Industry Has Been the Numerous New Ideas Developed in Relation to By-Product Coke Oven Practice.

By C. J. RAMSBURG
Vice President, The Koppers Company

A RESUME of the By-Product Coke Industry in 1921 indicates that there have been fewer ovens built during this year than in any year since 1914. This is largely due to the general business depression which has been prevalent throughout the country. According to the best information obtainable, the following ovens were completed during 1921:

Company	Location	No. of Ovens	Type of Ovens
Chicago By-Product Coke Co.,	Chicago, Ill.	100	Koppers
Camden Coke Company	Camden, N. J.	37	Koppers
Dominion Iron & Steel Co.,	Sydney, N. S.	60	Koppers
Milwaukee Coke & Gas Co.,	Milwaukee, Wis.	50	Koppers
American Coke & Chemical Co.,	Granite City, Ill.	80	Roberts
Cambria Steel Company	Johnstown	80	Semet-Solvay

Great Progress Made.

Although less construction work has been done, there has been great progress made in this industry during the past year by the development of new ideas in relation to by-product coke oven practice.

Underfiring Ovens with Producer Gas.

One great improvement has been the increased substitution of producer gas for underfiring coke ovens. At the plant of the Seaboard By-Product Coke Company, Jersey City, N. J., 6 Koppers-Kerpely Producers have been built, which furnish producer gas for underfiring 110 Koppers Combination Ovens. There has also been completed and put into operation a battery of 37 Koppers Combination Ovens for the Camden Coke Company at Camden, N. J., together with 4 Koppers-Kerpely Producers, which furnish gas for underfiring these ovens.

As in normal modern by-product coke oven practice, from 30 to 40 per cent of the total gas recovered in coking is returned to the ovens for underfiring, the importance of this development can scarcely be overestimated.

A few operating figures may be of interest in this connection:

Approximate amount of gas produced per ton of coke used in producers—150,000 cu. ft.

Average heating value of gas—129 Btu. per cu. ft.
Average analysis of gas:

CO ₂	2.5%
O ₂	0.5%
CO	30.0%
H ₂	10.0%
CH ₄	1.5%
N ₂	54.5%

Coke required per M. ft. of coke oven gas released—55.4 lbs.

Coke oven gas released per ton of coke used in producers—36,100 cu. ft.

A brief description of the producers erected at these two plants may be of interest as they are the first installations of this type of producer in this country. They are designed to use the small size coke, between blast furnace sizes and breeze, and each producer has a capacity for gasifying approximately 30 tons per day. The producers are of the revolving grate type with stationary water cooled shell built up as a low pressure boiler, which generates sufficient steam for the operation of the producers. The producer plant is also equipped with high pressure waste heat boilers, which furnish more than sufficient steam for the operation of the producer gas cleaning plant and gas boosters. The entire producer plant installation is of very rugged construction and equipped with all labor saving devices, which tend to reduce operating costs to a minimum.

Narrower and Higher Ovens.

Another feature of the year has been the completion and beginning of operation of plants consisting of the narrower and higher type of ovens. In the older type of Koppers oven, the height of coal mass has generally been approximately 8 ft. 10 in., whereas in the newer type of oven now in operation at Chicago, the coal mass has a height of 11 ft. These ovens have an average width of only 15½ in. It is now well established that the higher and narrower oven will give the best operating results.

Liquid Purification.

Another interesting feature of the year has been the development by the Research Department of The Koppers Company of a new method of purifying gas. The limited space available here does not permit a description of this process, but it has been well established in actual operation that the cost of purifying gas by this method is less than half the cost under the dry oxide purification method, with equally good results. This new, simple and inexpensive method of removing hydrogen sulphide from the gas will probably prove to be of great value to the steel industry.

New Construction.

There is very little new construction going on at the present time. The only ovens now being built are the remaining 100 Koppers ovens for the Milwaukee Coke & Gas Company at Milwaukee, Wisconsin, and the rebuilding of 30 ovens for the Woodward Iron Company at Woodward, Alabama, which is being done by The Koppers Company.

Summary.

On the whole, the By-Products Coke Oven Industry has come through the trying times of the past year in very good shape. The value of operating by-product coke plants in connection with the iron and steel plant has never been more conclusively shown, for, due to the great flexibility possible in by-product coke oven operation, it was a simple matter to adjust this to meet

the varying demands of the steel plants for coke and gas.

One deterrent feature has been the subject of freight rates. In many cases the existing rates have proven discriminatory in favor of the beehive coke. However, negotiations are now under way looking toward the adjustment of these rates, and it is believed that when this is accomplished it will have a favorable reaction on the By-Product Coke Oven Industry.

Recent Development in Steel Mill Cranes

Modern Improvements in Cranes Have Been Dictated Largely by
Three Aims, Safety, Accessibility and Standardization.

By GORDON FOX*

DURING the war period there was not a marked improvement in crane design and construction. The heavy demand together with the requirement for quick delivery resulted in cranes built largely to "manufacturers' specifications" and therefore largely duplicating previous practice. With the present competition the manufacturers are alert and receptive to the purchasers' desires. The present situation is therefore favorable to improvement.

Probably the most important recent development is the adoption by the Association of Iron and Steel Electrical Engineers at their Chicago convention of a standard code of specifications. This code is sufficiently liberal to warrant its general adoption, yet sufficiently specific to result in standardization along the lines of the "mill type" crane. This code will no doubt become more or less entrenched through its influence on state regulations.

Recent improvements in cranes have been dictated largely by three aims, viz., safety, accessibility and standardization. The trend is decidedly toward the inclusion of all reasonable safety features. More spacious cabs are provided to house magnetic control without unsafe crowding. Cabs of hot metal cranes are fireproofed and exits carefully provided. Wiring is more thoroughly enclosed in conduit and safety switches with locks employed. Limit switches are becoming quite universal although not always of satisfactory type. Gears are entirely covered and shafts and couplings are protected. Liberal walks with toe boards are more common and shields or plates are being put beneath parts which are liable to become loose and fall. These are but a few examples of the general trend.

Accessibility is being demanded in order that repairs may be more rapidly, safely and cheaply made. The older designs, more or less inaccessible, are becoming less acceptable. Attention is being directed to render the oiling of cranes more convenient so that it may be more safely and certainly performed. Provision is made on some cranes or their runways to afford better access to the end trucks and in a few instances platforms have been provided under the trolley to prevent the need of slings and scaffolds in reaching sheaves or other parts. "Fiddle string" trolley wires are now almost entirely

eliminated, being replaced by bars or angles and located above the bridge girder which are more easily accessible for cleaning or other repair.

The adoption of the A. I. S. E. E. code will further the cause of standardization through the adoption of standard shafting, couplings, gears, wheels and other parts. The significance of standardization is tremendous, particularly in the larger plants.

Of interest electrically is the almost universal use of dynamic braking with direct current hoist motors and the more frequent realization of the possibilities of adjustment for independent hoisting and lowering speeds. A new brake has been developed for hoist duty on alternating current cranes. This brake is designed to afford adjustable braking torque in lowering in addition to holding a fixed load. This brake makes possible the elimination of the mechanical load brake on alternating current cranes.

A few cranes have recently been constructed using ball or roller bearings, at least in part. It would seem that this type of bearing must establish superiority by decreasing maintenance rather than by reducing friction. The greater portion of a hoisting load is useful work. Much the greater portion of trolley and bridge loads are due to inertia. Flange friction is a more serious offender than bearing friction. The advantages of reduced bearing friction do not appear of pre-eminent importance.

There has been developed for the locomotive shop a four girder four trolley crane or a combination of two two girder, double trolley cranes arranged to permit hoisting the locomotive between the girders. This decreases the headroom and lowers the building cost. It also permits these cranes to be located on a lower runway, nearer the work.

COMPANY TRIES TO ENLARGE HOLDING

The American Rolling Mill Company, Middletown, Ohio, has made a definite proposition for the purchase of the assets of the Ashland Iron & Mining Company, Ashland, Ky. Should the deal go through, the American Rolling Mill Company will acquire two blast furnaces with a capacity of 100,000 tons of pig iron yearly; a practically new open hearth department, consisting of six 100-ton furnaces; a very modern blooming mill and six sheet mills.

*Mr. Fox is electrical engineer for the Freyn, Brassert & Company, Chicago, Ill.

Blast Furnace Department

Interesting Sintering Plant at Birdsboro, Pa.

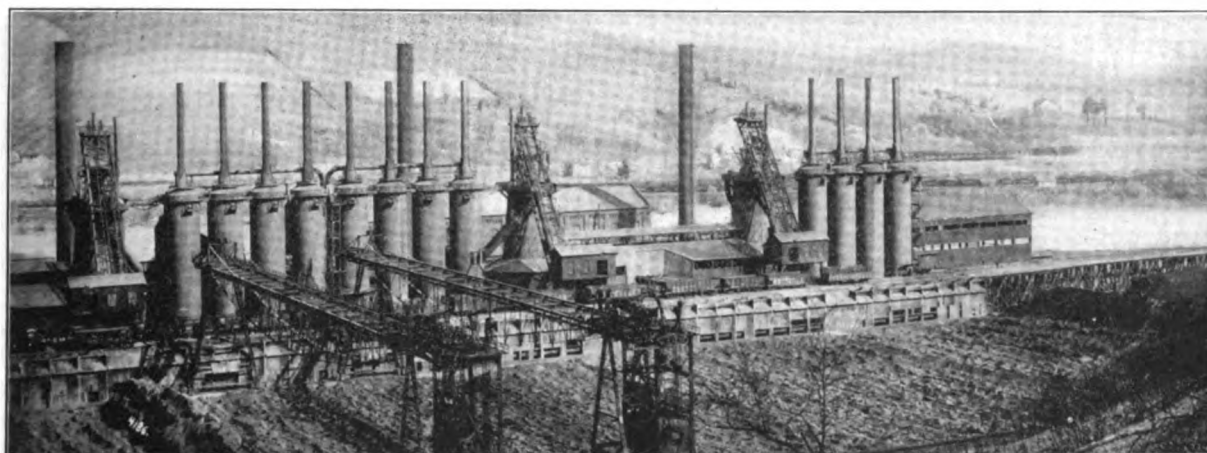
By B. G. KLUGH

Hot Blast Stove Rating

By F. H. WILCOX

New Blast Furnace at McKeesport

By DONALD N. WATKINS



Interesting Sintering Plant at Birdsboro, Pa.

Description of the Sintering Plant Built for the E. & G. Brooke Iron Company at Birdsboro, Pa.—Reclamation of Long Abandoned Iron Mine by Means of This Process.

By B. G. KLUGH*

THE new sintering plant of the E. & G. Brooke Iron Company at their Birdsboro, Pa., works is of interest from several standpoints. It functions in conserving and utilizing the iron ore resources, embodies the highest development of sintering plant engineering to date, and features an example of highly successful outgrowth of the entire historic background of sintering iron bearing materials.

It is of unique interest to preface the technical description of this plant with a brief recital of its fore-runners.

The first plant to operate on the down draft blast roast treatment of iron bearing materials was built at

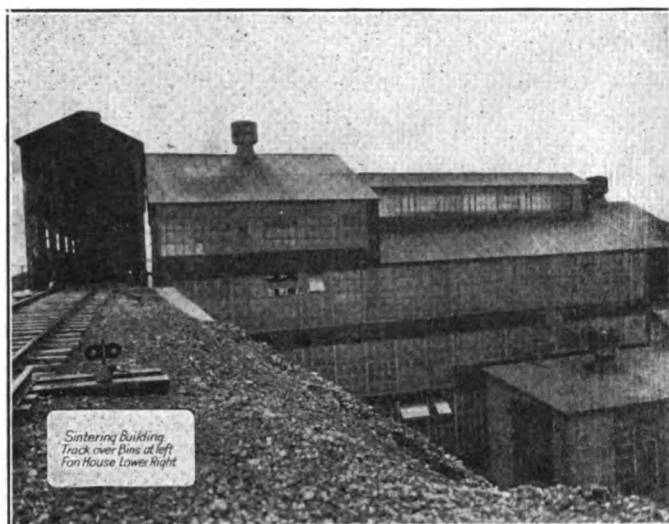


Fig. 1.

this works in 1911. Although of rather crude design inherent to initial installation, it operated quite successfully from the start, treating flue dust, both the current production and that of the stock pile, the latter being an accumulation of flue dust from the period of anthracite fuel to that time.

This plant was built and operated by the American Ore Reclamation Company on a conversion agreement with the E. & G. Brooke Iron Company. Although this first plant was naturally of rather crude design and construction, it was operated profitably until the entire stock pile was consumed and the furnace plant closed down for relining in September, 1912.

Operations were resumed in February, 1913. The plant was then operated on current flue dust from the E. & G. Brooke Iron Company's furnaces and on flue

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dust purchased from other furnaces in the district.

With the depletion of the flue dust stock pile, the necessity of finding other materials that might be profitably treated in this plant arose. The fact that the process simultaneously desulphurizes and sinters materials efficiently, had been established in numerous tests on this plant. The desulphurization of the French Creek ore bed had been anticipated as a possibility from the inception of this sintering plant.

The French Creek mines owned by the Brooke interests are located in Chester County about 10 miles from Birdsboro. Ore had been taken from this deposit dating back to Revolutionary days, and this specific mine was operated spasmodically for many years, with attempts at smelting the ore both raw and with various roasting processes. The high sulphur and great variation in lime content prevented their successful use, and although it was known that a large body of the ore existed, the results of their smelting had been so discouraging that they were abandoned in 1896. A further attempt to use this ore by preroasting in Giers kilns was made in 1898, but after a year's trial the mine was closed and considered permanently abandoned. During the interim, foreign and Lake Superior ores were used in the Brooke furnaces.

Tests showed that by crushing French Creek ore to $\frac{1}{4}$ -in. size and sintering with about $3\frac{1}{2}$ per cent carbon, the sulphur could be eliminated down to under 0.1 per cent. Furthermore, the fine crushing permitted the obtaining of a uniform mixture, eliminating the variation that existed in run-of-mine lump ores. An additional advantage obviously lay in the fact that while the dense lump magnetite presented very limited area of contact to the action of the reducing gases in the furnace, resulting principally in hearth reduction, high fuel consumption and low furnace production, the sintered product, consisting of cellular structure, presents great area of contact to the gases, with uniform resistance over the entire section of the stock column, obviating the inherently objectionable features to smelting massive magnetites.

With this in view, sufficient ore was taken from a stock pile that had lain at the French Creek mine for several years to make a sintering and furnace test on the French Creek ore.

The results were so satisfactory that the small sintering plant was taken over by the E. & G. Brooke Iron Company, and a crushing plant built to operate in conjunction with the sintering plant, for the treatment of their French Creek ore.

A number of improvements were made on the original plant, in the way of improved handling equipment, larger fans, better ignition equipment, larger and better pugmill construction, etc. The Brooke people further

made large investments toward reopening their mines and providing modern mining equipment. The development of these mines naturally required considerable time to attain an economical output.

The operation of this sintering plant, known as plant No. 1, was continued until April, 1919, during which period it produced over 200,000 gross tons of sinter.

The results obtained from the small plant were so satisfactory that it was determined to build a larger plant to meet the demand for a greater tonnage. This larger plant, known as plant No. 2, was started February 21, 1919.

This installation consisted of one American Ore Reclamation Company 42 in. by 57 ft. 4 in. machine of 200 square feet hearth area, with proportionate auxiliary equipment. The building was of wood construction and adjacent to the old sintering plant, so as to utilize the existing crushing plant. The new large plant was operated very successfully until totally destroyed with the crushing plant on May 5, 1920, after producing about 100,000 tons of sinter.

Notwithstanding the heavy loss sustained by this fire, the E. & G. Brooke Iron Company decided to build a larger and more modern plant immediately. This included a new and modern crushing plant, in conjunction with the sintering plant, the description of which forms the basis of this article.

The crushing plant deserves a special article for its description, hence will not be described here. Its design and construction by Messrs. W. B. Devereux, Jr., of Wilkins & Devereux, 120 Broadway, New York City, and M. T. Hoster, manager of mines, for the company, embodies the latest development in crushing, screening and handling equipment. The crushers and rolls in this plant were designed by the C. G. Buchanan Company and built by the Birdsboro Steel Foundry and Machine Company.

The run of mine ore is delivered from standard gauge cars into a track hopper, and from there by a series of continuous steps, the material is screened and crushed automatically, and the product of minus $\frac{3}{8}$ -in. crushed ore is delivered by means of an inclined conveyor onto a shuttle belt, which distributes it among the sintering plant bins.

Storage Equipment.

There are 8 bins, arranged in a straight line, each of 200 tons capacity and of circular section. The tops of the bins are covered with cast iron grating, with 2-in. square openings, all continuous. A standard gauge track is provided over the two end bins for discharging flue dust, fine sintering fuel, return fines or other materials directly thereinto. The entire bin equipment is housed in a steel building arranged at a right angle to the sintering building proper. This covering extends over the top of the bins with ample head room to admit a locomotive to run thereinto.

Feeding and Proportioning Equipment.

Each bin is served at its bottom with a revolving disc feeder of the American Ore Reclamation Company design. The feeders are in principle the same as that in many other sintering plants, with the exception of the drive. This drive consists of a worm gear mounted on main drive shaft. The latter shaft runs the full length of the bins, and each worm is independently provided with a jaw clutch by which any one of the feeders may be thrown in or out of service without disturbing the others.

This arrangement makes it possible to eliminate the double reduction used where bevel and spur gear drives are used, and provides simplicity in that only one shaft, through the line of bins is necessary. Notwithstanding the rather wide objection to worm drives, this was installed, using a very heavy cast iron worm and gear. The plant has been in operation for some time and no signs of under wear on the slow moving, positive, and non-vibrant drive have appeared. This type of feeder embodying a positive volumetric feeding device was originally developed by the American Ore Reclamation Company and is in use in 15 plants, including the recently described plant of the Cambria Steel Company. Slight differences in the details of the method of driving this feeder exist in the various plants.

Collecting Belt.

All of the eight feeders discharge onto a 30-in. belt conveyor which is located parallel to the line of feeders. The conveying side of the belt is arranged under the discharge edge of the feeder discs, so that no spouts or skirt boards are required to prevent spillage. The material as delivered from the several feeders onto the belt forms a continuous stratified layer, which is maintained in a uniformly proportionate mixture as discharged from the belt.

Bucket Elevator.

The collecting belt discharges into the boot of a belt bucket elevator, consisting of a 20-in. heavy rubber belt with 18-in. style B malleable iron buckets, spaced about 18 inches apart. The elevator is wholly enclosed in steel plate casing and slightly inclined. The upgoing strand is provided with supporting idler pulleys, having bearings and lubrication outside the casing. The elevator runs at a speed of 250 rpm. The performance is highly satisfactory, having no objectional spillage or tendency to clogging.

Distribution of Elevator Discharge.

Provision is made for distribution of the sintering mixture, as discharged from the head of the elevator, to two sintering machines. This consists of a mechanically operated oscillating cutter gate, in the discharge spout of the elevator, which divides the stream into two parts, each being delivered through two sections of a bifurcated spout onto respective inclined conveyors. The two conveyors are each about 6 ft. 6 in. centers, and are 24 in. wide, and discharge directly into the pugmills.

Pugmills.

The pugmill is of the latest cast iron body, double shaft type, having been designed in all details by the engineering department of the American Ore Reclamation Company. It is practically a duplicate of those in the new sintering plant of the Cambria Steel Company, as well as in other new plants. It was built by the Duncan Foundry & Machine Company of Alton, Ill. The cast iron body, connecting the two heads rigidly, prevents the vibration which was found objectionable in the older steel plate types of pugmills.

This quiet running mixing element performs its function of continuous mixing, moistening, and conveying almost ideally.

Sintering Machine.

This machine is of the standard American Ore Reclamation Company type B 42 in. by 57 ft. 4 in. design. Although the plant is laid out and all auxiliary equipment constructed for two machines, only one was installed for the present.

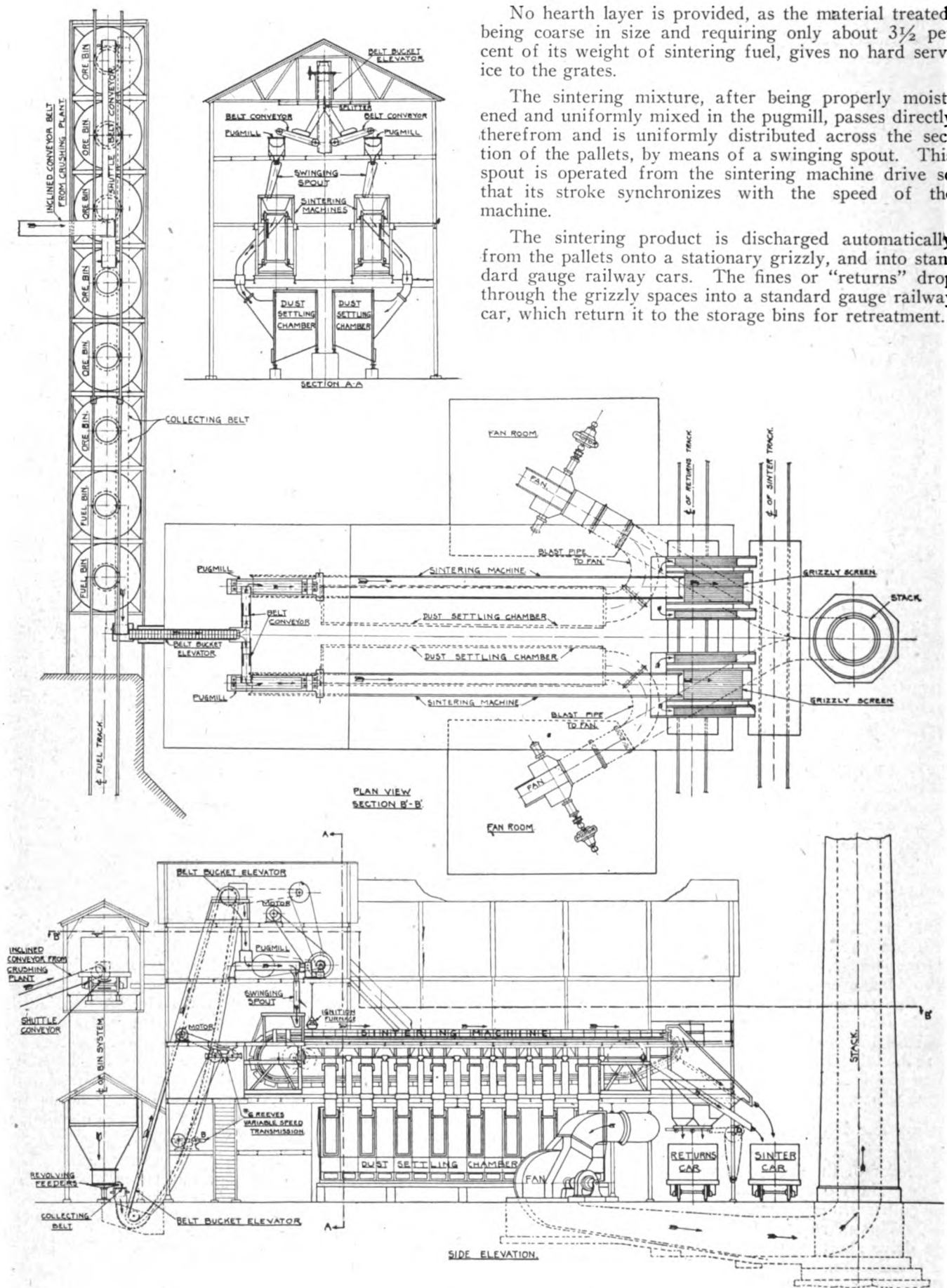
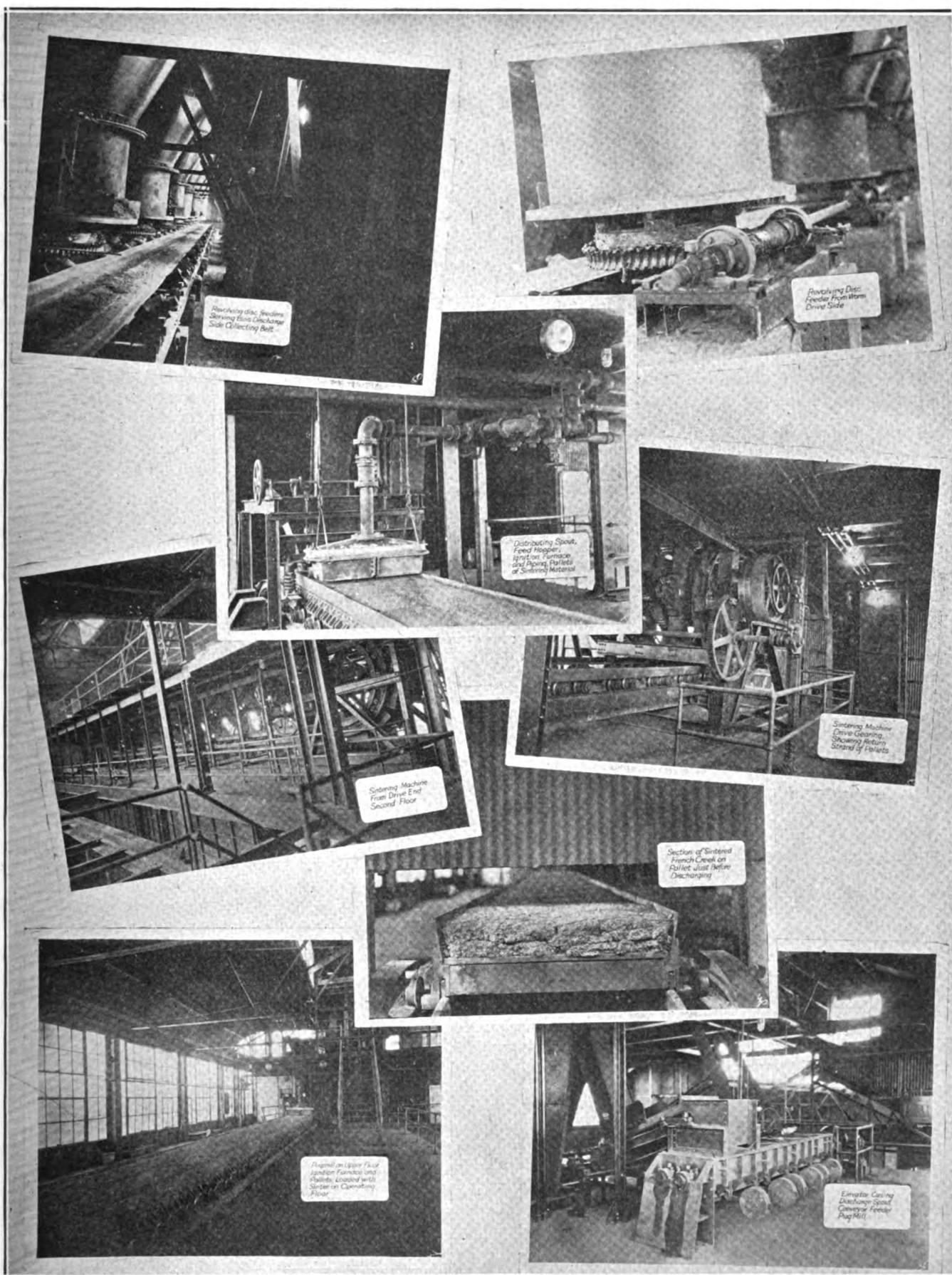


Fig. 2—General Plan of Sintering Plant.

No hearth layer is provided, as the material treated, being coarse in size and requiring only about $3\frac{1}{2}$ per cent of its weight of sintering fuel, gives no hard service to the grates.

The sintering mixture, after being properly moistened and uniformly mixed in the pugmill, passes directly therefrom and is uniformly distributed across the section of the pallets, by means of a swinging spout. This spout is operated from the sintering machine drive so that its stroke synchronizes with the speed of the machine.

The sintering product is discharged automatically from the pallets onto a stationary grizzly, and into standard gauge railway cars. The fines or "returns" drop through the grizzly spaces into a standard gauge railway car, which return it to the storage bins for retreatment.



Ignition System.

The initial ignition is performed with illuminating gas, but provision is made for the use of blast furnace

gas when the furnace is in blast. The piping is so arranged that illuminating gas may be momentarily turned on during short periods of interruption of supply

of blast furnace gas. This may be accomplished by opening and closing of valves with no interruption of the continuous sintering operations. The standard A. O. R. Co. type of ignition furnace is used, which performs equally well on any gas or oil ignition, and gives a uniform controllable ignition of exactly the required intensity.

Suction System.

Each of the nine windbox pipes is connected into a large cast iron dust collector, which is located below the sintering machine floor and parallel with the machine.

This dust collector is of a larger size than is usually constructed, and provides ample volume for settling out substantially all of the dust which drops through the grates or is entrained with the exhaust gases.

This dust collecting chamber is provided with a sloping side, and continuous cleaning doors, so as to empty the dust collected therefrom in least possible time.

The gases are taken from this chamber at the discharge end of the machine, being conducted through a 5-ft. diameter main directly into a 100 diameter fan of the new sintering design. The fan is of the center plate wheel, double inlet type, and has a capacity of 60,000 c.f.m. when working under 20-ft. w.g. suction. It was furnished by the American Blower Company of Detroit, Mich. The bearings are of double sleeve, water cooled, spherical self-aligning type. The fan is directly connected through a flexible coupling to a 350-hp. induction motor.

The gases from the fan pass through an underground flue and out through a brick stack 7 ft. 6 in. diameter by 160 ft. high. The high stack is necessary to prevent the sulphur bearing gases from the desulphurization of the ore from settling in objectionably concentrated form in the immediately surrounding vicinity.

Synchronous Drive and Control.

The automatic control of synchronizing the volume of material fed to the demands of the sintering machine and simultaneously and independently controlling the proportions of the various materials in the sintering mixture, is accomplished positively and accurately. A 30-hp. motor drives a No. 6 Reeves variable speed controller "A." This Reeves "A" drives the sintering machine through its variable speed shaft, which also drives a second No. 6 Reeves controller "B," which through its variable speed shaft drives the feeders and collecting belt. In this way any change in the speed of the sintering machine, by adjustment on controller "A," produces a corresponding change of speed of the feeders. On the other hand, if it is desired to change the volume of material being delivered by the feeders to meet differences in the demands of the sintering machine, this is accomplished independently of the sintering machine speed by adjustment of controller "B." After such adjustment, the synchronism of the speed of the feeders (and resulting volume fed) will continue to be automatically controlled by any changes in the sintering machine speed by adjustment on controller "A." The proportion of the various materials fed from any or all of the eight bins is regulated by means of independent gates on each of the feeders.

The controls governing the synchronizing of the above factors, as well as that of the moistening, ignition, depth of charge, etc., are very handily arranged on the

operating floor, so that one operator has quick control of all factors, and observation from a single point.

Special Features.

The simplicity and accessibility of all mechanical elements, including drives, gearing, and all moving parts, is especially notable in this entire plant.

The extremely small number of moving parts in this plant, with the achievement of every degree of desired flexibility, and at the same time of large production and smooth operation, with its comparative absence of dust and noise, makes it a pleasing demonstration of the development of the art.

The very small operating force required is a predominant feature. The illumination of the plant is very uniquely and effectively executed. The liberal use of frosted wire glass sash on the building sides gives ample light to all parts in daylight, and flood lights arranged at the end of the building illuminate the operating floors completely and without undue glare or shadows.

The construction is of structural steel, with plate floors throughout.

The fan rooms are of brick, practically dust tight construction, and are arranged adjacent to the sintering building, thus eliminating unnecessary length of blast piping.

Performance.

This plant has for its primary function the beneficiation of the French Creek ore, which as before stated is practically valueless in its raw state as a blast furnace material. At the present time high carbon flue dust is being used as a source of sintering fuel, thereby reclaiming the iron values of the flue dust simultaneously with the desulphurizing and beneficiating the ore. This flue dust is obtained from the E. & G. Brooke Iron Company's own furnace as well as that from neighboring furnace plants. A typical analysis of the French Creek ore and the sintered product is as follows:

	Raw French Creek Ore	Sintered French Creek Ore
Fe	52.70	54.80
SiO ₂	11.50	12.90
Al ₂ O ₃	2.10	2.50
CaO	1.70	2.30
Sul	2.60	.10
P	.040	.050
Mn	.15	.21

The capacity of this plant with the single machine is 500 tons per day, and with the second machine 1,000 tons per day.

Personnel.

The executive credit of this entire development is largely due to Mr. Robert E. Brooke, under whose business direction all the enterprises involved, from the small plant in 1911 up to the present stage, have been conducted.

The construction work was done under contract of Hughes, Foulkrod & Company, Pittsburgh.

The engineering and design was performed in collaboration and consultation with the American Ore Reclamation Company.

Hot Blast Stove Rating

Actual Test Data Showing the Effectiveness of Hot Blast Stove Equipment as Applied to a 600-Ton Blast Furnace.

By F. H. WILLCOX*

ANY reasonable expense that leads to measurable worth while economy in blast furnace plant operation is justifiable in the construction or rehabilitation of the plant. The factors that make for economy are large tonnage of good quality iron, low fuel consumption, low cost of handling materials and ability to consummate sales and purchases to advantage. It is not infrequently overlooked that a blast furnace plant is not built to make pig iron but is, or should be, built to make money. Therefore, expense in equipment or construction which looks toward a betterment in the rating of any of the above four factors must, or should be, undertaken only upon the basis of evidence which will support the contention or belief that certain improvements will sufficiently reduce certain items of pig iron cost to enable a plant to meet the market with a materially better margin between cost and sales price.

A policy of parsimony in the fittings of a furnace plant is rarely conducive to the satisfactory realization of any of the first three of the factors cited above. On the other hand, prodigality in the fittings of the plant stands an even greater presumption of inability of costs meeting the market. In this case, unwarranted expenditures have been committed in an endeavor to reduce the force to a number actually below the number of men reasonably required, not for operation but for the not infrequent contingencies and emergencies that arise. Consequently it is not safe to avail oneself of the possible reduction contemplated in the planning of the plant. Or similarly ill considered expenditures are made to secure the last increment in increase of efficiency of pumps, hoists, blowers, boilers, generators and similar items of equipment. Consequently the fixed charges against a kilowatt, or boiler horse power, or 1000 gallons of water, cause the total cost to be actually in excess of the cost of equivalents from considerably less efficient equipment. Quite obviously, similar contrasts may be brought out in the design and fittings throughout any plant.

Quantity production of good iron with low fuel consumption reverts to management—materials and equipment being equal. Given good coke, good furnace lines and good management, the coke consumption will depend upon the heating capacity of the stoves. It is quite unnecessary to speculate any more about how much heat a set of hot blast stoves should be able to impart to the blast. For furnace lines as developed today, for ore allotment received from the lake region, and for quality of coke approximately indicated for the vast majority of operations, a set of hot blast stoves should be able to continuously carry 1250 deg. F. straight line heat, with a margin of heat reserve. Of course the heat actually to be carried cannot be predicted. The only fact actually available is

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that good stove practice is to carry as much heat as good furnace practice will allow, or if the furnace takes the heat good, to burden the furnace as heavily as possible on as high a blast temperature as it is possible to uniformly hold, with maintenance of reserve heat for emergencies.

Singularly enough, it is a fact that those plants doing outstanding work are not at all necessarily those carrying the highest stove heats, and this leads to a continual misapprehension of the value of large stove capacity. However, a determination of the facts shows that in the greater number of cases those plants having the best heat equipment have the best coke consumption. In cases where this is not true there is trouble with quality of coke or distribution. Even where plants with good heat equipment show good coke practice, the effectiveness of the equipment is not at all necessarily disclosed by the average heat carried. Quite frequently they run on moderate or moderately high heats only, high heats being used but a small fraction of the time. The writer has experienced more than one instance where after expenditures have been made for gas cleaning and increased heat equipment, and where the coke consumption had been reduced even radically, it was difficult to attribute the gains to the expenditures simply because the very moderate increase in average blast temperature was entirely out of line with the saving in coke effected. Rather naturally the impression is gained that considerable expenditures have been made and little advantage gained in heat. Of course, as a matter of fact, the increased heat reserve, some days not employed at all—other days desperately required and available, has actually effected the betterment. For perhaps the majority of operations the above practice is the most practical method of utilization of good heat equipment. Plants long equipped with good heat equipment are as a rule those working along the line of a gradual increase in average temperature of blast. Other factors, however, have to be brought into line with this tendency.

One may say, therefore, that expenditures put into good heat equipment are paying. Considering that entirely adequate and good hot blast stoves for a new plant cost less than ten per cent of the cost of the plant, it is clear that provision of absolutely full measure of heat equipment is a phase of planning and construction where tonnage and quality of iron as well as low coke consumption are quite largely determined. Liberality in stove equipment is an insurance at no considerable increase in plant cost. The day of extravagance in construction is certainly gone for some time to come. Therefore, the equipment must be put in with some degree of precision.

This tabulation is an analysis of the effectiveness of hot blast stove equipment commonly put in for furnaces designed for 500-600 tons of pig iron per day. For maximum load conditions, the higher tonnage is taken as a base.

EFFECTIVENESS OF HOT BLAST STOVE EQUIPMENT.

600-Ton Furnace Basis—44,000 cu. ft. wind per min.

Stoves 22 ft. diameter by 100 ft. high. Two-pass, side combustion.

1. Size Checkers	3½ x 3½"	4 x 4"	4½ x 4½"	5¼ x 5¼"	6 x 6"
2. Thickness of Brick	2"	2½"	2½"	3"	3"
3. Checker Openings	1000	715	616	445	373
4. Area Checker Openings.....	85 sq. ft.	79 sq. ft.	87 sq. ft.	85 sq. ft.	94 sq. ft.
5. Heating Surface in Checkers.....	93,400 sq. ft.	76,200 sq. ft.	73,900 sq. ft.	62,200 sq. ft.	59,800 sq. ft.
6. Cu. ft. Brickwork in Checkers	10,000 cu. ft.	10,400 cu. ft.	9,850 cu. ft.	10,000 cu. ft.	9,300 cu. ft.
7. Weight Brickwork in Checkers.....	1,280,000 lb.	1,335,000 lb.	1,265,000 lb.	1,280,000 lb.	1,195,000 lb.
8. Ratio Heating Surface to Cubic Contents	9.34	7.34	7.50	6.22	6.40
Operation on three stove basis. Stove on gas 240 minutes. Stove on blast 120 minutes. Blast temperature—1250 deg. F.					
9. Cu. ft. Wind per Ton Iron.....	105,000	105,000	105,000	105,000	105,000
10. Heat in 44,000 cu. ft. Blast for 120 min. at 1250 deg. Blast Temp....			110,000,000 Btu.		
11. Cu. ft. Gas Required Per Min.....			6,900 cu. ft. per stove		
12. Total Heat in Gas.....			158,000,000 Btu.		
13. Ratio Heat Input and Output to Heating Surface	1190	1440	1490	1760	1840
14. Ratio Heat Input and Output to Weight of Brick.....	86	82	87	86	92
15. Average Velocity per Second of Gas in Checkers.....	7.50 ft.	8.10 ft.	7.35 ft.	7.50 ft.	6.85 ft.
16. Heat Input Rate per sq. ft. Heating Surface per min.....	4.92 Btu.	6.03 Btu.	6.20 Btu.	7.37 Btu.	7.65 Btu.
17. Drop in Temperature of Brick within 1" of Heating Surface.....	330 deg.	410 deg.	435 deg.	640 deg.	675 deg.
18. Ratio Total Heating Surface to cu. ft. Wind per min.....	6.40	5.20	5.05	4.25	4.10
19. Ratio Total Cubic Contents Checkers to cu. ft. Wind per Ton Iron..	0.285	0.292	0.282	0.285	0.266
20. Ratio Total Cubic Contents Checkers within 1" Heating Surface to cu. ft. Wind per Ton Iron.....	0.285	0.238	0.215	0.147	0.138
Operation on Four Stove Basis.					
21. Heat in 44,000 cu. ft. Blast for 60 min. at 1250 deg. F. Blast Temp..			55,000,000 Btu.		
22. Cu. ft. Gas Required per minute....	4600 cu. ft.	4600 cu. ft.	4600 cu. ft.	4600 cu. ft.	4600 cu. ft.
23. Total Heat in Gas.....			79,000,000 Btu.		
24. Ratio Heat Input and Output to Heating Surface	595	720	745	880	920
25. Ratio Heat Input and Output to Weight of Brickwork.....	42	41	83.5	43	46
26. Drop in Temperature within 1" of Heating Surface	165 deg.	205 deg.	218 deg.	320 deg.	338 deg.
27. Velocity per sec. of Gas in Checkers	5.8 ft.	6.2 ft.	5.65 ft.	5.8 ft.	5.25 ft.
28. Heat Input Rate per sq. ft. Heating Surface per minute.....	3.28 Btu.	4.02 Btu.	4.14 Btu.	4.92 Btu.	5.10 Btu.
29. Ratio Total Heating Surface to cu. ft. Wind per min.....	8.50	6.92	6.70	5.68	5.42
30. Ratio Total Cub. Contents Checkers to cu. ft. Wind per Ton Iron..	0.381	0.396	0.375	0.381	0.355
31. Ratio Total Cub. Contents Checkers within 1" Heating Surface to cu. ft. Wind per Ton Iron.....	0.381	0.315	0.287	0.196	0.185

The compilation involves an assumption of identical efficiency for all stoves. This cannot be a fact but it involves only the factors under Items Nos. 15 and 27.

Some significant factors are immediately apparent. The cubical contents of the checker brickwork in the second pass is substantially equivalent from a 3½"-square 2"-wall checker to a 6"-square 3"-wall checker. On the other hand, the heating surface suffers a radical and progressive decrease. This results in a lower and lower ratio of heating surface to cubical contents. Were all the cubic contents of brickwork in the stoves of equal utility or efficacy, this would mean that all of the designs would possibly give the same amount of

heat, although with a decreasing heat efficiency and increasing use of gas, approximately correspondingly directly and inversely proportional to the ratio of heating surface to cubic contents. This indication is confirmed in Item No. 13, Ratio Heat Input and Output to Heating Surface, and in Item No. 16, Heat Input Rate per sq. ft. Heating Surface per Minute. Here it will be noted that with increasing size of checker opening and increasing size of brick, an increasingly heavier rate of storing and releasing of heat is imposed upon the heating surface. Were the heat transfer from the incandescent brickwork to the relatively cool blast concerned only, the surface will be found quite adequate. But, in the heat transfer from incan-

descent gases of combustion to brick surfaces continually more nearly approximating the temperature of the gas, experience shows that a heat in put rate of 5.0 Btu per minute per square foot is as high as the rate may be pushed, unless reasonable efficiency is to be adversely affected.

The efficiency of the stoves is also somewhat influenced by the average velocity of gases of combustion in the checkers, Item No. 15. There being in all designs a large number of checkers, one segment of which is near the draft door, then if quite slow velocities are employed there is a distinct tendency of the gases to wander, to much passing down the checkers nearest the draft openings. This tendency is counterbalanced by these same checkers becoming relatively hotter due to the excess incandescent gas passing through, when the cooler checkers will have more nearly taken their proportion. Therefore, within reason, the higher the velocity the more utility will be experienced of all the checker openings and the corresponding brick surface and volume. Also, when there are large checker openings the velocity should not be slow because there does not seem to be enough tumbling of the gases induced to get all molecules of the descending gas stream fully and repeatedly in contact with the brick surface.

Fixing attention on the brickwork weight or volume in the stove, Item No. 14, Ratio Heat Input and Output to Weight of Brick, and Item No. 19, Ratio Total Cubic Content Checkers to Wind per Ton of Iron, signify an equivalent and adequate amount of brickwork to store up the necessary heat to be imparted to the blast. In this connection, however, it is well to bring in the fact that not all of the volume of the brick is equally effective. The following table shows the rate of heat input and output in machine made steam pressed brick:

Brick Exposed to Gas Flame.

	Temperature		
	Face.	1" From Face.	2" From Face.
One hour	1850	1250	770
Two hours	2000	1450	1075
Three hours	2000	1600	1250
Four hours	2000	1640	1325

Brick Exposed to Cold Blast.

	Temperature		
	Face.	1" From Face.	2" From Face.
Start	2000	1640	1325
One hour	800	1250	1280
Two hours	400	800	900

Several tests along these lines have brought about a tacit basing rate that the effective brickwork in stove checkers is that amount within one inch of the heating surface.

With this base, Item 19—Ratio Total Cubic Contents Checkers to cu. ft. Wind per Ton Iron, shows the rapidly decreasing amount of actually effective brickwork in the checkers with increasing size of checker and increasing thickness of brickwork. Item No. 17 shows the unfortunate result of this fact. 400 deg. is, in an entirely practical way, the limit in drop of temperature of stove brickwork. Any particular margin over this results in inability to carry a straight line heat and entire absence of a heat reserve.

Putting aside further analysis, it is apparent and may be stated that in a hot blast stove, a study of economical use of brick and space inside the shell emphasizes that only the heating surface of the brick and the brick within one inch of heating surface are of any value. This would be reached to the greatest degree by 2" checkers and 2" openings. As this is not practical, one can only make the checker walls as thin as is consistent with strength, and the checker opening as small as is consistent with cleanliness of the gases, and accuracy of dimensions obtained in brick manufacture. Apparently, the design shown under 3½" x 3½" checkers embodies to the greatest degree all the important advantages and high ratings in heating surface, effective cubic contents of brickwork, low heat transfer rate, and low temperature drop. It has a considerable heat reserve. All requirements for good heat equipment are found in a battery of three stoves. There are no other types of lining adequate in a three stove equipment unless the area of the stove checkers, or its height, be increased by approximately twenty-five per cent.

There are certain serious objections to a battery of but three stoves. Since the checkers must have small openings the gas must be very clean, not to exceed 0.25 grains dust, or the checkers will plug up, the stoves will have to be taken off for cleaning, and there will be recourse to but two stoves, one on blast and one on gas. Unless a forced gas burner is used, insufficient gas can be forced into the stove in the two hour period to carry an adequate blast temperature for the following two-hour period. Unless the brick dimensions are very nearly correct, less than 2 per cent deviation, the checkers may shift and partially close up the checker opening. Repairs that take a stove off blast seriously impair good furnace practice. A 2" checker brick is more apt to fail, both structurally and from the effect of heat, alkaline salts and dust, than a 2½" or 3" brick.

If past experience, which has very satisfactorily proven the practicability of the small checker stove, does not suffice to establish certainty as to soundness of investment in and construction of this type, then the only recourse is to four stoves. An increase in size of checker, thickness of checker brick and consequent increase in diameter and height of stove does not, in any sense, get away from the occasional use of two stoves.

An increase to four stoves is an increase of thirty-three per cent in heat equipment cost, or about three and one-half per cent increase in cost of plant. If this investment is to be made, it should at least be made wisely. A study of the tabulation under four stove equipment heading indicates that any of the designs are quite adequate, all four stoves being in service. However, in view of the apprehension of a stove going out of service if only three were installed, it would be a bit short-sighted to ignore the possibility of having to operate on three stoves. Therefore, one ought to so provide that if operations are reduced to three stoves, then they will suffice to at least carry the usual heat, but now with no reserve capacity to speak of. Referring to the three stove tabulation, it will be seen that either a 4" or 4½" checker with a 2½" brick will accomplish the desired results.

On a single furnace plant, there is no doubt but that the four stove equipment is a better insurance. It is perhaps the last word in insurance but if there

does not have to be rigid economy, it is as good a place to carry an excess cost as anywhere in the plant. If there does have to be economy, the $3\frac{1}{2}$ " checker three stove is clearly indicated. It has worked out satisfactorily. Of course there also has to be a really effective gas cleaning installation. However, this is true of any size checker up to 6" opening. In conjunction with the choice of three stoves, on the basis of a $3\frac{1}{2}$ " checker opening, it is to be kept in mind that such equipment is an excellent base on which to start with the expectation of a two furnace plant. This would have a complement of seven stoves of this type for two furnaces, thereby assuring three stoves per furnace.

The cost of any one of the above types is substantially equal. The shell and stove trimmings are the same, and the number of brick in ring walls, piers, arches and combustion chamber lining are identical. The number of 9" equivalents in the checkers is substantially equivalent, though of course there is more labor in setting 9" x 6" x 2" checker tile than $13\frac{1}{2}$ " x 6" x 3" checker tile, there being so many more of the former.

Not less important than utilizing the volumetric capacity of a given stove shell to the utmost practical advantage is the necessity of correct hot blast stove design and construction. Designs should be chosen which embody every precaution and advantage developed as the result of practical experience in construction, service, operation and repair. The loads and stresses in the brickwork of hot blast stoves are not static loads but by reason of the alternate heating and

cooling of a large mass of brickwork, may be termed "live." It is disregard of this fact that has led to not infrequent most expensive failures. The most usual points of failure, refractory quality aside, are springing and collapse of combustion chamber walls, breakdown of tile, secondary and primary arches, and piers in the bottom of the checkers, shifting of checkers, uncompensated expansion of ring walls and checkers, and failure of dome and dome base.

In an operating way, the usual handicaps in effective use of large quantities of gas are fluttering and surging of the gas flame at the burner and in the combustion chamber, ineffective use of full checker area, limited capacity to take gas when the occasion arises, and insufficient draft due to restricted and small chimney valves, draft chambers and stacks.

The quality of refractories used in hot blast stoves is very important, and here too experience is the best guide. Probably the best practice and construction today involves the use of four qualities of firebrick. Experiments are being carried out with new materials, for this particular use, which may mark a distinct advance.

The writer hopes to have pointed out the advisability of adequate investment in good heat equipment, to have analyzed possible types, to have indicated a logical choice of stove equipment, and especially the importance of choosing designs which from the construction standpoint embody features grounded in practical operation, construction and repair developments for the fixing of some of the somewhat intangible requisites for durable and serviceable equipment.

New Blast Furnace at McKeesport

The National Tube Company Rebuild Blast Furnace No. 3 at Their McKeesport Plant from the Ground Up—All the Improvements Have Not as Yet Been Completed.

By DONALD N. WATKINS

ONE of the most important of the recent improvements completed by the National Tube Company at their McKeesport, Pa., plant was the building of a new blast furnace on the site formerly occupied by the old No. 3 furnace. The old furnace was blown out July 1, 1920, and construction work was immediately started on the building of the new furnace. This was completed and put in blast November 15, 1920.

The rebuilding of this furnace was in keeping with the general policy of the Steel Corporation, which is to improve all blast furnaces as the opportunity presents itself.

The history of the original No. 3 blast furnace is very interesting and dates back to the year 1889, when its construction was first started. As will be seen from the following record, it has had a remarkable run:

RECORD

Blown in.....Dec. 4, 1890
Blown out for relining.....April 26, 1894

Blown in.....Sept. 7, 1894
Blown out for reconstruction...Sept. 19, 1900
Ten feet added to its height, relined and changed from a vertical to a skip hoist.
Blown in.....Jan. 26, 1901
Blown out for relining.....June 21, 1904
Blown in.....July 28, 1904
Blown out for reconstruction...Nov. 16, 1907
New shell constructed and relined.
Blown in.....June 14, 1909
Blown out.....July 1, 1920

As will be seen from the above record, the furnace had been in the same jacket for the past 13 years and it was deemed necessary to rebuild the entire furnace and its auxiliary equipment at this time only because it was impossible to secured increased hearth area by relining.

The program of improvements originally included the building of a new stack, down-comers, dust-catcher, and

gas-cleaning equipment, along with the reconstruction of the four stoves. Up to the present time the new stack, the down-comers, and the dust-catchers only have been completed.

The old stack was completely demolished and a new one erected from the foundation up. The new furnace has a height of 90 feet, hearth and bosh diameters of 18 feet and 22 feet respectively, and has an 80-degree, 32-minute bosh angle. The shell is of unusually heavy construction, being made up entirely of 1-inch plates except the bottom ring, which is $1\frac{1}{4}$ inches thick.

The hearth jacket is of water cooled cast iron construction, 6 inches thick with $1\frac{1}{4}$ -inch tuyere pipe cast in. The new lining involves a total of 484,000 bricks, and gives a furnace capacity of 24,000 cubic feet. The stock lined protection consists of 7 courses of steel cast wearing plates 3 inches thick, 33 to the course imbedded in the brick. The large bell is 13 feet in diameter. The McKee revolving stock distributor is electrically driven and controlled.

Harbison-Walker bottom blocks, 18x12x8 inches are used. All refractories used in the lining of the furnace were furnished by the Harbison-Walker Company.

Several interesting features stand out most prominently in the construction of this stack. To begin with, it is a hand filled furnace, that is it is hand filled in the stock house; has a McKee distributor which helps to preserve the furnace lining and increases the production; and the stack is built, as stated above, along unusually heavy lines.

There are four explosion stacks equipped with safety explosion valves. The four down-comer branches leave the explosion stacks at about 31 feet above the top of the furnace and connect in pairs to form two down-comers. All pipes are lined with $4\frac{1}{2}$ -inch fire brick.

The dust catcher is built of $\frac{1}{2}$ -inch steel plate and lined with $4\frac{1}{2}$ -inch fire brick. It is also equipped with an explosion valve at the top. The dust catcher is 22 feet outside diameter and 25 feet high. The two down-comers enter at the side and the gas leaves the dust-catcher at the top.

There are four stoves used in connection with the furnace. Three of these, which are of the side combustion, two-pass Cowper type, and were originally constructed in 1889, are to be rebuilt in the immediate

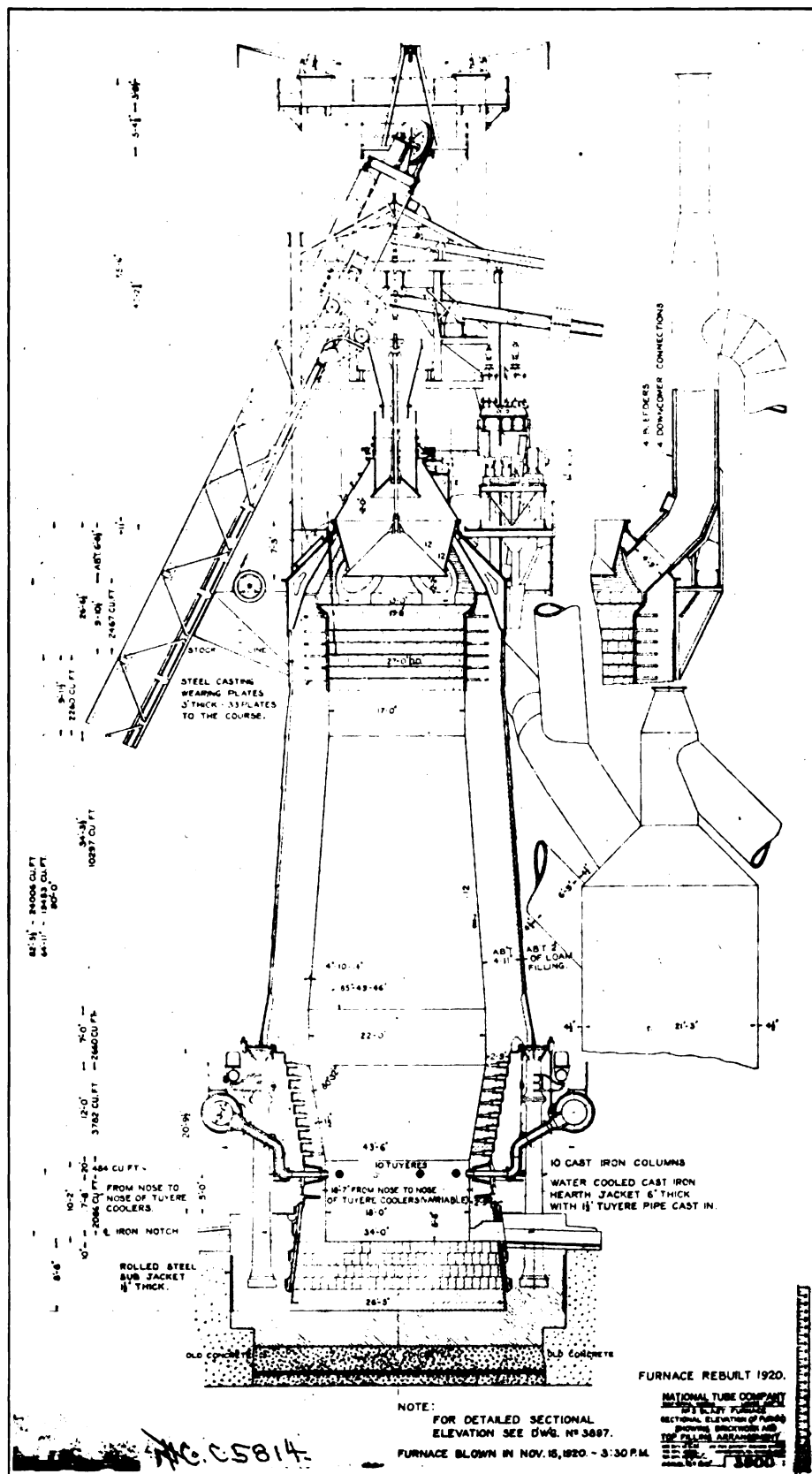


Fig. 1—Section through the new stack.

future. The fourth stove, which is of M. and C. three-pass design, was built at a later date. The real capacity of the new stack has not as yet been tested due to the fact that the old stoves have not sufficient heating surface to test the new furnace.

The building of the furnace was directly under the supervision of the Engineering Department located at the National Works. Mr. A. L. Hoerr is the chief engineer of this plant. In the designing of the new stack

the Engineering Department was ably assisted by ideas and suggestions advanced by the operating officials of the blast furnace department, of which department Mr. M. R. Stevenson is the superintendent.

Hammer-Welded Steel Pipe

Hammer-Forging Can Be Adapted to the Manufacture of Pipe from 24 to 96 Inches in Diameter—The Process, the Materials Used, Characteristics of the Pipe and Its Testing Briefly Described.

THE Process of making lap-weld pipe by hammer-welding is relatively new as compared with the butt-weld and lap-weld processes and the sizes made by hammer-welding are, relatively, much larger in diameter.

The pipe is made by bending a steel plate into tubular form with edges overlapping and then welding the overlapped edges after they have been heated, by hammer-forging them on an anvil block supported on a horn inside the pipe.

The process of hammer-welding is particularly well adapted to the manufacture of pipe in sizes from about 24 to 96 inches. Due to the simplicity of manufacture—in that rivets, projecting ribs, and other objectionable features are eliminated—hammer-weld pipe has a relatively high efficiency.

The strength and ductility of the material, the sound and smooth-welded seam, the simple and efficient types of joints that can be used, and other advantages make hammer-weld pipe desirable for almost any purpose requiring large diameter pipe.

Manufacture and Materials.

The plates used in the manufacture of this pipe by the National Tube Company are made in accordance with A. S. T. M. Specification A-78-21T and are of open hearth steel of a grade to give the best results in welding and other manipulations in manufacture. The plates may either be bent cold, or heated and bent, depending upon their thickness.

The tubular, or cylindrical form is obtained by bending the plate on long horizontal rolls, in much the same manner as plates are bent for boiler shells and tank construction. However, they are bent completely around until the edges overlap to the required extent and the proper diameter of the pipe is obtained. In

certain sizes, two or more plates may be used with similar overlapped edges. Sufficient lap is allowed to make sure that the force of the welding hammer will be most effective in wedging the edges together.

The rough tube thus obtained is taken to the welding machine where a short section of the overlapped edges is heated to a welding temperature by water gas burners, placed opposite—inside and outside the pipe. After reaching the proper temperature, the heated portion of the seam is hammer-forged on an anvil supported by a long counterbalanced beam, after which the contiguous portion is heated and welded. The welding machinery is developed to a point which allows the operator to direct every blow with the accuracy of the skilled smith with his sledge. The power hammer can be operated at a high rate of speed and can be regulated to hit with the varying degrees of force necessary to make a strong weld.

After being welded, the pipe is placed in an annealing furnace and heated to a temperature to remove strains and refine the grain. It is then subjected to another operation on horizontal rolls to round up the pipe, straighten it, and remove such scale as may have formed during manufacture.

When the pipe has been welded, annealed and straightened, it is given a

preliminary inspection. The ends are then trimmed to any desired angle or length.

Each length of pipe is subjected to an internal hydrostatic pressure test. The pressure varies from 150 to 2,000 pounds per square inch, according to the size and wall-thickness of the pipe and the service for which it is intended.

After the hydrostatic pressure test, the pipe is given a thorough inspection as to surface, finish and dimensions and a protective coating is applied if required by the customer. The pipe is then stenciled with the name of the manufacturer and the pressure applied in testing, after which it is ready for stock or shipment.

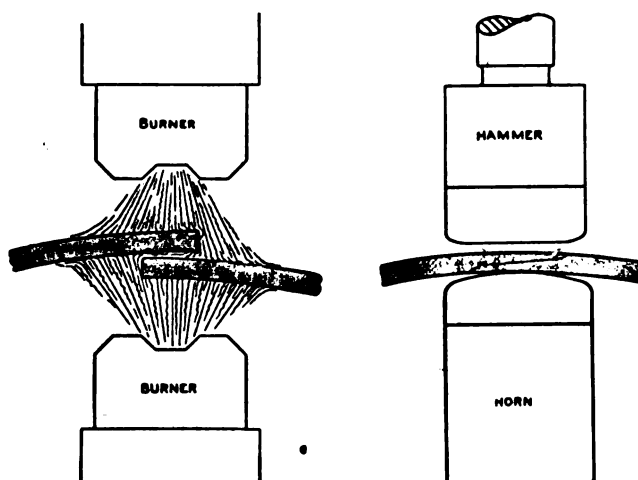
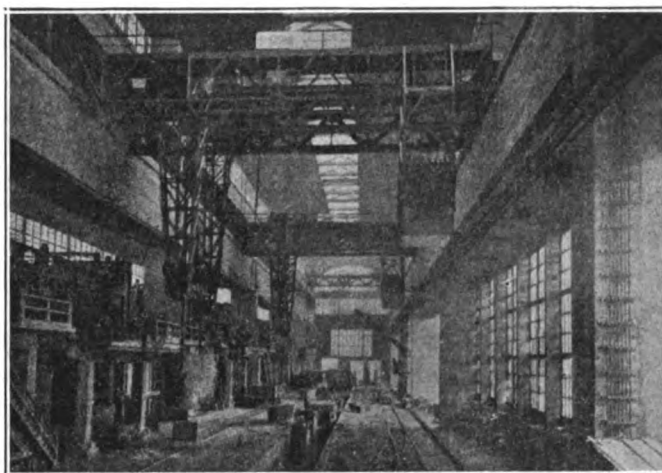


Diagram illustrating principle of hammer-welding. The left-hand drawing shows water gas burners heating the overlapped edges of the tube, inside and outside. Note the flame is directed on all surfaces of the portion to be welded, thus insuring uniform temperature. After heating, the hammer, shown in the drawing at the right, forges the overlapped edges into a strong weld on the anvil block which is supported by a long beam or horn.

Abstract of Bulletin No. 13, entitled, "Hammer-Welded Steel Pipe," published and copyrighted, 1921, by the National Tube Company, Pittsburgh.

Steel Works Department



Recent Developments in Open Hearth Furnaces
By HENRY WILLIAM SELDON

Progress of Electric Steel Furnace
By EDWARD T. MOORE

Manufacture of Commercially Pure Iron
By D. M. STRICKLAND

The Acid Electric Steel Process
By R. J. WEITLANER

Open Hearth Furnace Makes a Record

**Graphical Treatment of Stack Gas Analysis and of
Fuel Gas Analysis**
By W. TRINKS

Recent Developments in Open Hearth Furnaces

Open Hearths Were Standardized Along Modern Lines During the Past Year—Open Hearth Hourly Tonnage Increased 115 Per Cent During Year.

By HENRY WILLIAM SELDON, B.S., Met. Eng.*

FOR many years open hearth furnace construction followed the same general plans and each furnace performance was judged by the records of the past. Starting with the war time conditions there arose a demand for increased tonnages per unit. The scarcity and high price of coal, oil, gas, etc., caused a demand for better fuel economy.

Fathered by these conditions it is not surprising that we have had new as well as old ideas tried out. Under the conditions existing in many plants heretofore the suggestion or development of new or so-called radical ideas was not encouraged, with the result that we made but little advancement in open hearth practice.

In order to convert an inefficient open hearth into a thoroughly modern one the following items should be carefully considered:

- | | |
|-------------------|-------------------------|
| 1. Hourly tonnage | 8. Burners |
| 2. Fuel economy | 9. Uptakes |
| 3. Valves | 10. Slag pockets |
| 4. Sewers | 11. Charging machines |
| 5. Checkers | 12. Doors, frames, etc. |
| 6. Ports | 13. Gas producers |
| 7. Roof | 14. Bottom making |

1. Hourly Tonnage.

The hourly tonnage or tons/hour output of an open hearth furnace has been increased as much as 115 per cent.

2. Fuel Economy.

The fuel economy has been surprising and as an example we give the following from producer gas results. For a long time 550 pounds of coal per ton of steel was considered good practice. With the latest practice this figure has been reduced to 350 pounds/ton.

3. Valves.

Valve builders and designers have been striving to attain a product which would be simple to operate, thoroughly reliable and could be easily and quickly repaired.

The designs most favored at present are water sealed, instantaneous mechanical reversing, fuel saving, having ample port areas, offering minimum resistance to flow of gases and occupying minimum floor space.

4. Sewers.

The trend in sewer design has been toward increased size and straight lines with the elimination of sharp angles and obstructions. Considerable change has taken place in producer gas main design. The value of over-size mains, easy curves, ample soot catchers and suitable burning out facilities is being recognized. Overhead

mains and interchangeable producers are advocated.

5. Checkers.

The checker problem is an individual one for each plant to solve by experience.

The tendency is towards the use of thinner brick with an increase in the vertical dimensions of settings.

The use of checker brick having a higher refractoriness than fire clay is advocated with the idea of imparting a higher preheat to the incoming gases.

Oversize checker chambers are being used to advantage. During the early run of a furnace the excess number of checker flues are covered with tile. As the furnace ages and the draft becomes impaired these tile are removed. Numerous schemes are in use for cleaning the checkers without taking the furnace off.

The effect of checker resistance to the gases passing through is more generally understood and influences the type of setting.

6. Ports.

The ports on a producer gas furnace have ever been the cause of much trouble and loss and it has not been long since the life of the port governed the life of the roof and in cases the life of the furnace. With the present ports this is not the case and the ports outlive several rebuildings.

The original brick gas port has been gradually reinforced by water cooling until the bricks become the minority. Many plants still prefer to do their own water cooling with curved pipe at the nose, but the commercial water cooled ports are gradually winning out.

The latest ports are designed with the idea of securing quicker and more perfect fuel burning and of the numerous types being developed much has already been accomplished. The heat time as well as the amount of fuel per ton has been materially reduced.

7. Roof.

The ribbed roof is now firmly established in open hearth practice and the debated points are mainly as to the length of brick.

Researches are being made to find a brick which will possess all the good qualities of a silica brick and in addition have a fusion point considerably higher. This search is not being confined to the so-called cheaper materials alone, but to the high priced refractories which have previously only been used for special work.

In a few shops the bonded roof has been adopted with excellent results.

Experimenting is also being done to determine the most efficient height to build the roof to secure better fuel burning.

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8. Burners.

Burner design has received special attention and has resulted in a big saving of fuel. The heat times have been reduced and the utilization of fuels and combinations of fuels has been made possible which had previously been impossible.

9. Uptakes.

The uptakes of the present day open hearth are being made the objects of much changing. The general trend is toward increased area.

In several of the newer types of furnace the air uptake area is controlled by the installation of either slide or mushroom dampers which cannot be connected with the reversing mechanism.

The air uptake designs vary from a single uptake which extends across the entire end of the furnace in one case to another in which a portion of the air for combustion is by-passed and introduced into the gas port at an angle a short distance behind the nose.

The aim of each design is to obtain "blow pipe action," thereby securing quicker combustion and intense sectional heating which results in faster melting and, with the proper regulation better fuel economy.

It has been demonstrated that it is possible to obtain this desired action by the proper port design.

The use of a fan for introducing the necessary air for combustion under pressure is the plan adopted in several designs, but this method is still detrimental to furnace life.

10. Slag Pockets.

Slag pocket design has been advancing along the lines of increased size and speed of cleaning.

Modern practice demands the frequent removal of the slag without taking the furnace off for minor repairs.

There are numerous methods of water cooling in the slag pockets for accomplishing this purpose. Interchangeable buggies are also used for this purpose.

11. Charging Machines.

Mechanical charging machines have practically eliminated the old hand charging process. The machine most

preferred at present is the low type and one in which the operator and control is separated from the peel. The demand is for faster machines and stronger motors.

12. Doors, Frames, Etc.

The change in this equipment has been to water cooling and larger sizes. Some progress has been made in making the frames in more than one piece. Cast and welded steel are used in excess with many buckstays still made from slabs and structural shapes.

Water cooling equipment is being used for bulkheads, slag lines, back walls and chills in addition to those mentioned.

13. Gas Producers.

Mechanical gas producers have practically eliminated the old hand operated machines in all of the larger plants.

This has been caused by the desire to produce more and better gas from a given unit and the difficulty of securing competent and reliable operators.

There are a number of makes of full and semi-mechanical producers on the market in which the gas making operations are done mechanically.

All the latest types are water sealed and use a mixture of steam and air. In addition to a steam jet blower a turbo blower is supplied with facilities for admitting live steam to the blast.

Any producer requires experienced and careful operation and the quality of the coal used is also important.

14. Bottom Making.

Considerable experimenting has been done to develop a satisfactory mechanical means for making bottom. Several devices are available for patching the back wall slag line.

The inability to secure Austrian magnesite for bottom making resulted in the development of our American magnesite deposits. Numerous substitute materials were put on the market for this purpose with varying degrees of success. This condition had the effect of forcibly demonstrating to open hearth men the value of good dolomite and the proper care of the bottom.

Progress of Electric Steel Furnace

Although Progress in Electric Steel Furnace Development Has Been Slow During Past Year, Writer Looks for Greatest Developments to Take Place as Business Situation Improves.

By EDWARD T. MOORE*

SINCE its inception about 40 years ago, the progress of development of the electric steel furnace has been one of unusual activity, especially the decade 1909 to 1919.

The year 1920, and more especially the year 1921, will no doubt go down in history as the low-water mark in the growth of electric furnaces since the beginning of its phenomenal advancement over 10 years ago.

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The beginning of this rapid growth dates back to the first commercial electric furnace in the United States for melting and refining steel at the works of the Halcomb Steel Company, Syracuse, N. Y., from which the first heat was tapped on April 5, 1906. Since this time there has been a rapid development in technical and operating details, resulting in furnaces of greater capacity being constructed, as the following table will indicate:

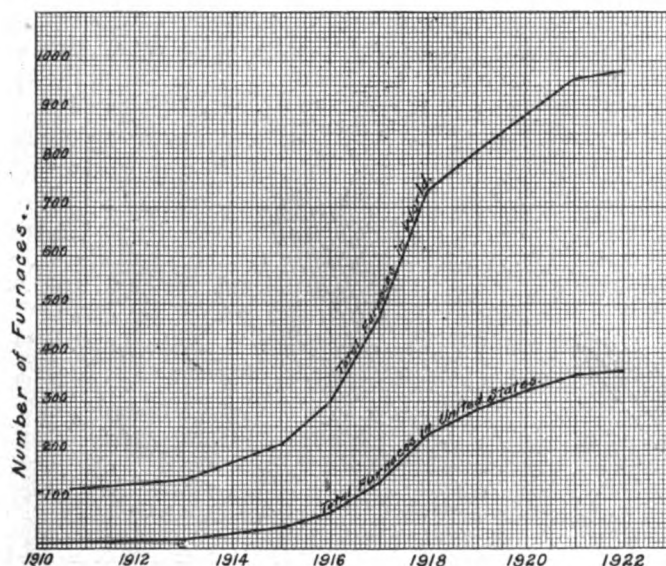
Location	Capacity Tons	Date when first heat was tapped
Halcomb Steel Company...	4	April 5, 1906
Illinois Steel Company....	15	May 10, 1909

Carnegie Steel Company... 25
U.S. Naval Ordnance Plant 40

Nov. 17, 1916
Feb. 2, 1921

A further indication of the progress of the electric furnace can be gained from Figs. 1 and 2. In 1911 there were only 10 electric steel furnaces in operation in the United States, and the steel produced in them amounted to 29,105 tons. By 1915 the number of furnaces had increased to 41, and the production to 69,412 tons. In 1917 there were in operation 136 furnaces producing 304,543 tons. By 1919 the furnaces numbered 287 and the output was 566,084 tons. On January 1, 1921, 356 furnaces were installed or contracted for in the United States.

In the early days of the electric furnace, a number of single phase units of comparatively small capacity were put into use and are still in service. To date there are approximately 37 single phase furnaces installed as against 319 polyphase units. Since January 1, 1918, so far as can be learned, only five single phase steel furnaces have been installed in this country. It is interesting to note also that of the 356 furnaces now installed,



Electric Steel Furnace Development.
Figure 1.

151 are in plants having two or more furnaces each, the number of such plants totaling 55.

As has been noted in the table above, the tapping of the first heats from two 40-ton Heroult steel furnaces at the U. S. Naval Ordnance plant, South Charleston, W. Va., on February 2, 1921, marked a considerable step forward in electric furnace construction and in the electrometallurgy of steel and iron. This is probably the greatest development during the year just passed and consequently is of great interest and value, not only to the electrical engineer, chemist, and metallurgist, but, in this specific case, to those concerned in the manufacture and application of ordnance and armor.

These 40-ton electric furnaces are operated in conjunction with two 75-ton basic open hearth furnaces using natural gas of 950 to 1000 Btu., and after dephosphorizing, the molten steel is transferred to the electric to be desulphurized, deoxidized, and brought to the final temperature preparatory to teeming and casting.

Each electric furnace is basic lined and has a transformer capacity of 3300 kva. The transformers, built

by the General Electric Company, are water-cooled 3 phase units with a primary for 6600 volts operation and taps arranged so that full input can be obtained at 100 or 90 volts as desired in the furnace, the last connection giving 21,200 amperes per phase.

All the electrical equipment used with these furnaces is practically standard, including the regulators, switch-board and meters.

One of the furnaces is equipped with 24-in. diameter amorphous carbon electrodes and the other one with 14-in. diameter graphite electrodes, thus giving current densities of 46.8 and 137.5 amperes per square inch respectively with the transformer at its maximum output of 21,000 amperes per phase. Some very excellent data has no doubt been secured on the relative electrode consumptions, breakage, and other troubles causing delays.

While these furnaces are of the largest capacity yet installed, negotiations are under way, it is understood, to install 60-ton electrics in Henry Ford's plant at River Rouge, so that the year 1921 will be notable principally for the development of larger capacities.

Reactance.

Considerable study has been made of the reactance of furnace circuits and much improvement secured by properly installing this feature. The reactance must be depended upon to limit the value of the current surges that may occur during the melting down portion of the operating cycle. These surges may be due to pieces of metal falling against the electrodes and causing momentary short circuits, or to establishing the arc, after it has been broken by the rapid melting away of the metal. The frequency and duration of these surges depend largely on the care used by the operator in charging the furnace. During the refining period, surges are of much smaller magnitude and very much less frequent, so that the value of reactance used, while usually the same, should preferably be reduced, with much improvement to power factor.

Power factor and reactance are intimately connected, and considerable harm has been done by advocating too high a power factor. Public reference was recently made to the unsatisfactory operating characteristics of a 3 ton, 3 phase, 100 kva. furnace taking power from a 11,000 volt, 25 cycle circuit. On account of the low reactance of this equipment, it is common occurrence for the oil breaker to open several times during a heat, and as this breaker is set at six times normal current a reactance of approximately 16 per cent is indicated, which should give a power factor of over 98 per cent—a figure unnecessarily high.

If the reactance was doubled, the power factor would be still approximately 95 per cent, while the short circuit current would be decreased from 600 per cent to 320 per cent. If the reactance was still further increased to 43.6 per cent the power factor would still have the excellent value of 90 per cent and the short circuit current would be 229 per cent. This seems to be a desirable value although if still better protection is desired, such as on a small capacity privately owned plant, a reactance value of 53 per cent would give a power factor of 85 per cent and a short circuit current of 190 per cent. These figures are based on values that would be obtained with a reactance having the characteristic of the air core type, which is generally used in furnace installations, and would necessarily be altered for iron core reactors and reactors of the compounding type, such as saturated reactors.

A 6 ton, 3 phase furnace having transformer capa-

city of 1500 kva. on a 60 cycle circuit will have approximately 90 per cent power factor, indicating a reactance of 43.6 per cent, of which about 6 per cent will be in the transformers. The remaining 37.6 per cent reactance, which is principally in the secondary leads, would be reduced to 15.7 per cent on a 25 cycle circuit. The 25 cycle transformer would have a reactance of about 7 per cent, which, added to the 15.7 per cent, would give a total of 2.7 per cent, indicating a power factor of 97.4 per cent with a corresponding short circuit current of 440 per cent. This indicates that to give the smooth operation of a 90 per cent power factor furnace, a 20 per cent reactance should be added to a furnace that normally required no exterior reactance on a 60 cycle circuit. Considerable thought has been given by the writer to a type of reactor having a normal reactance value at rated capacity, but a much higher reactance at overloads and also a reduced reactance at reduced load. The graph (Fig. 3) illustrates the relation between reactance and power factor in a circuit. As abscissae are plotted reactance voltages in percentage of the supply voltage, while the ordinates represent the power factor of the circuit in per cent. Incidentally, the ordinates of this curve also indicate the voltage drop due to resistance in the circuit, or, neglecting the resistance in the transformer and furnace leads, the actual voltage which is obtained across the furnace electrodes in per cent of the supply voltage.

Electrodes.

One of the largest cost items in the manufacture of steel by the electric furnace comes from electrodes, and users of this material have not been careful enough in the past in regard to the handling and proper use of them. In spite of every precaution taken by the manufacturer, careless storage or handling of electrodes by the user will cause trouble. The desirable characteristics of an electrode are:

1. Low electrical resistance.
2. Slow rate of oxidation.
3. Strength to withstand the handling received during transportation, installation, and operation.
4. Low heat conductivity.

The prevention of abrasions on the outside surface of electrodes should be particularly guarded against as serious local heating results and hence increased oxidation with attendant excessive electrode waste. The electrode manufacturers have done considerable work toward improving the quality of their product and by increasing the density, much better results have been secured. A specification on furnace electrodes made up by the Electric Furnace Committee of the Association of Iron and Steel Electric Engineers, while an initial effort, will serve as a valuable guide in checking and inspecting electrodes. This specification also outlines a method of determining electrode resistance and specifies that amorphous carbon electrodes should have an average specific resistance of not more than .002 ohm per inch cube at 20 deg. C., with no single electrode above .0025 ohm. With graphite electrodes the average specific resistance should be .00036 ohm per inch cube.

A new development within the past several years which has met with success in the ferro-alloy industry and which has possibilities of being extended to the electric steel furnace is the Söderberg self-baking continuous electrode. This electrode consists of a steel tube filled with prepared carbonaceous material which bakes itself in the furnace in which it is used. Extensions are made to the tube by welding in place and without interfering with the operation, and the tube then filled. As the bot-

tom portion within the furnace burns away the new portion eventually reaches a point within the furnace where baking results, after which it reaches the zone of use. A great economy in electrode cost has been obtained with this type in ferro-silicon furnaces in Norway, and it has been demonstrated in this country at Anniston, Ala., with very favorable results, we understand. On account of the present necessity of using a metal tube or jacket, it is questionable if it could be used successfully in steel furnaces. With some modifications, however, it no doubt can be adapted for the steel furnace and should eliminate the present costly delays due to electrode handling and breakage.

Regulators.

It is the duty of the regulator to so control the position of the electrodes automatically with respect to the furnace charge that one component of the power input will remain substantially constant, regardless of other conditions within the furnace. On account of the mechanical and electrical inertia of the system, a time lag

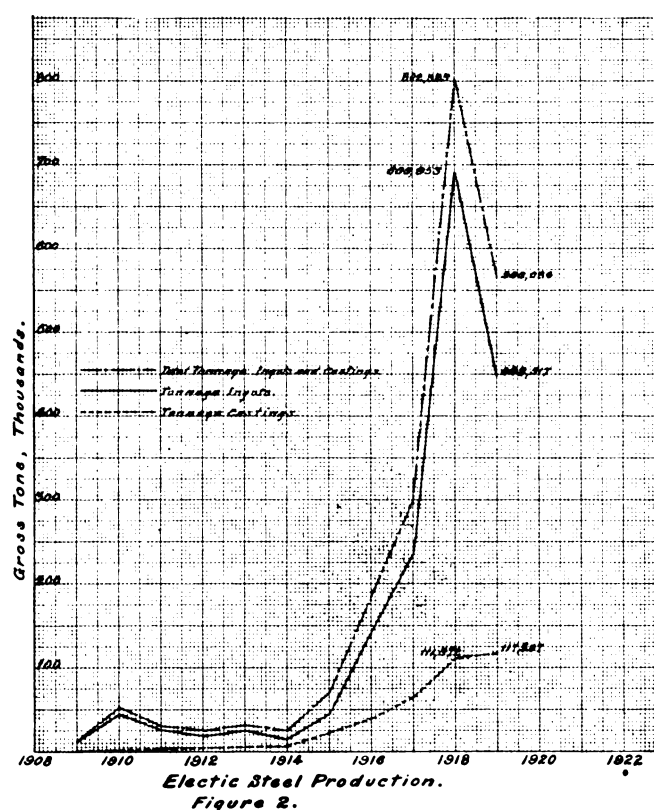


Figure 2.

exists between the change of the regulated quantity and its effect on the position of the electrodes, and in attempting to obtain high speed and precision, a condition known as "hunting" is invariably encountered. When an elementary control is employed to maintain an unstable quantity constant, it is necessary to either operate at low speeds, or to be satisfied with reduced accuracy, or to strike a compromise on both. Owing to the inertia of the moving parts, however, the electrode motor will drift somewhat, and if a fairly high electrode speed is used, the electrode will over-travel a sufficient amount to change the regulated quantity to the opposite side of its normal value.

In order to combine the advantage of high speed and at the same time eliminate over-travel of the electrode, the Westinghouse Electric & Manufacturing Company has developed a new regulator which allows the elec-

trode motor to operate continuously, and the electrodes at high speed, until the current reaches to within approximately 15 per cent of its normal value. Between this 15 per cent point and the normal value of the current the regulator assumes a vibrating condition, and the electrode motors are subjected to a series of impulses, the average time the motor is connected to the circuit being a function of the amount the furnace current deviates at any particular instant from its normal value. There are two distinct stages, therefore, in the operation of the regulator, one being the continuously running stage and the other the vibrating stage. The vibrating feature permits the motors to operate at a high speed until the current in the electrode has been brought back to within approximately 15 per cent of normal, when the speed is gradually reduced to zero. High speed and freedom from over shooting are thus obtained.

Action is secured by current and voltage coils, the current coil being connected as usual and the voltage coil connected between the electrode and furnace shell. On account of the voltage element, it is impossible for the

veloping resistor is a liquid, which responds to these forces more readily than a solid. Such forces may be usefully applied to cause the liquid metal to flow rapidly through the heat-developing resistor, thereby enabling the furnace to be forced, and to cause a strong upward circulation in an adjoining bath, by which the metal is refined of suspended impurities and made homogeneous. Reference is made to the well known "pinch effect" as well as the newer "corner effect" and "stretch effect." Much opportunity remains in this field of high current density to study the existent mechanical forces, but great perseverance is necessary on the part of the investigator as direct experiments are tedious and difficult, as so many foreign factors are likely to enter to mask the results. The majority of these forces probably increase with the square of the current, and may therefore not be very evident until the currents become very large.

Induction Steel Furnace.

The first ones to recognize the possibility of heating by induction currents were deFerranti and Colby, and it is generally conceded that the basic use of the transformer principle to electric furnaces was independently applied by both of these inventors in 1887, the dates of their patent applications being but a few months apart. Their design, however, was never put to practical use although some of the early principles adopted by Colby closely resemble present day apparatus and probably because of the more practical nature of his developments was awarded the Franklin Institute Medal for his induction furnace.

After the first early developments of the induction furnace it seemed to be overshadowed by the success of the arc furnace, as prior to 1914 the largest unit of the induction type in the United States had a capacity of only two tons. The inherent low power factor of the furnace and the difficulty of maintaining a satisfactory refractory lining were greatly responsible for this lack of development.

In 1914 two induction furnaces of 20 tons capacity were installed and at that time were the largest of any type in the United States. This supremacy continued until the installation of a 25-ton Heroult furnace in 1916. These 20-ton induction furnaces were of the two-ring type and in operation utilized single phase current of five-cycle frequency at 5000 volts with a special motor-generator set having an output of 4000 kva. at 5000 volts, 5 cycles and driven by a three phase, 25 cycle, 2300 volt synchronous motor. In operation the furnace rings are charged with molten metal, every part of which is thereby subjected to intense, uniform and positively controlled heat, and is then poured off after a treatment lasting from 60 to 90 minutes.

These large size induction furnaces have not been entirely successful and, it is understood, have been out of service for some time. The refractory expense in these large furnaces is very high and for general work the arc furnace has been found quite superior. This relationship may be changed in the future for special applications as a two ton induction furnace developed by the General Electric Company has recently completed a run of 555 heats on one lining. This is exceptional performance, especially when we consider that each heat consisted in melting high silicon steel scrap on a magnesite lining; but as the desired results could not be obtained readily in any other way it was necessary to follow this apparently incongruous practice. Assuming the same results could be obtained with the arc furnace, the lining cost of induction furnace is considerably below the single

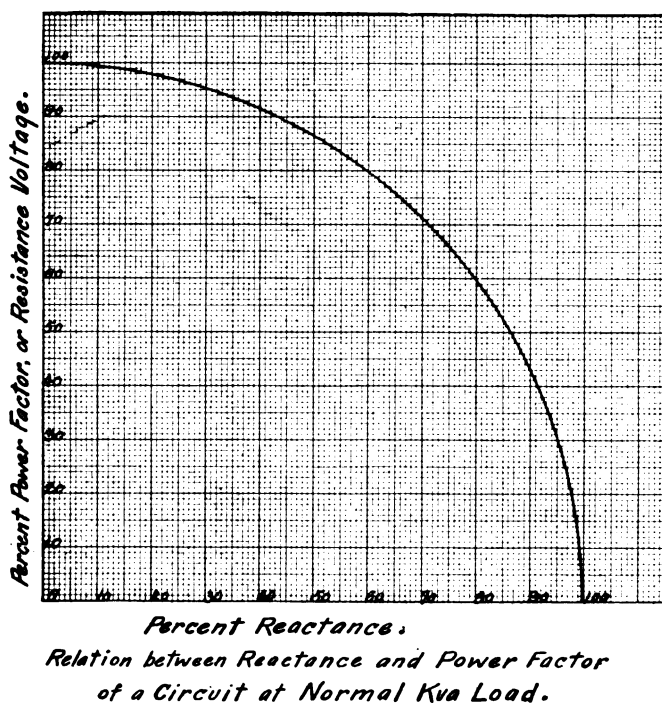


Fig. 3.

electrode to dip into the bath and is an advantage, particularly when producing low carbon steel. This voltage element in the control of each electrode makes each unit independent of the others, and in addition serves as a no-voltage release.

It is said that the new features of this regulator permit the furnace to be placed on automatic regulation on a cold charge immediately, and in cases where the electrode bores into the charge, which later falls in around it and causes the breaker to trip out, that the regulator will act to extricate the electrode in a large majority of cases before the breaker is tripped.

Electrodynamic Forces.

In a paper presented before the American Electrochemical Society, Dr. Hering discusses a number of quite recently discovered mechanical forces in electric furnaces which are of electric origin. These forces may be made use of, or may be detrimental, in some types of electric furnaces, chiefly those in which the heat-de-

item of electrode cost in the arc furnace, while the figures for power consumption are comparable. The development of a new furnace lining called "furnite" has done much to render this furnace successful, and unquestionably larger units of this particular type will be forthcoming.

Conclusion.

Of necessity this review must be incomplete as many developments are not learned till long after their inception and usually a considerable time elapses between the inception and application to actual practice. Those desiring to pursue this subject further may do so by referring to the articles in the bibliography following, to the authors of which we are indebted for much of our information.

It would be a great mistake to surmise that the rather retarded progress during the past year foretells any slowing down of progress in electric steel furnace development. Indeed, it rather lays emphasis on how far and how fast the art has advanced. During periods of relative inaction, such as the past year, a great deal of thought and conception is taking place and when finances are such that these theories may be tried out in

practice, we are bound to reap in the harvest, not far distant, the results of our work at this time.

Bibliography.

The Electric Melting Furnace as a Central Station Load, *General Electric Review*, June, 1921, Vol. 24, No. 6. H. A. Winne.

The Largest Electric Steel Furnaces, *General Electric Review*, September, 1921, Vol. 24, No. 9. J. A. Seede.

Electric Furnaces from the Furnace User's Standpoint, *Report Electric Steel Furnace Division, N. E. L. A.*, C-9-20. Edw. T. Moore.

Electrodynamic Forces in Electric Furnaces, *Transactions American Electrochemical Society*, 1921. Carl Hering.

The Status of the Electric Steel Industry, *Iron Age*, 1921, Vol. 107, No. 1. E. F. Cone.

Electric Furnace Committee Report, Association Iron and Steel Electrical Engineers, September, 1920, Vol. 2, No. 9. Edw. T. Moore, chairman.

The Carbon Electrode, National Carbon Company bulletin. Graphite Electrodes, Acheson Graphite Company booklet. Electric Furnace Usage, *Electrical World*, Vol. 77, No. 2. Editor.

The Regulation of Electric Steel Arc Furnaces Using Movable Electrodes, *Transactions American Electrochemical Society*, 1921. W. G. Mylius.

Manufacture of Commercially Pure Iron

Departures from the Usual Manufacturing Procedures in Making Pure Iron—Analyses Show Difference Between Common Steel Slags and Commercial Pure Iron Slags.

By D. M. STRICKLAND*

DURING the mythical days, so vividly described in "The Arabian Nights," it would have only been necessary in order to obtain commercially pure iron that Aladdin rub his old lamp and request the appearing genii to respond with a delivery. However, this was a long, long time ago. The gnomes and fairies no longer respond to the demands of mortals, so mankind, denied the privilege of simply asking for its requirements, has been forced to develop and produce life's comforts and necessities wholly unaided by supernatural powers.

In fact, hundreds of years have passed since the famous old lamp ceased to function. Consequently, the abilities of men have been steadily increasing until today the products of their achievements far surpass the most fantastical or imaginative myth ever dreamed by a Persian nobleman. It has remained for the scientists of the twentieth century to perfect the methods of ore reduction and purification to the high degree where it is possible to produce commercially pure iron economically and in quantities sufficient to successfully bring this product to the attention of present day users.

Needless to say, the development of commercially pure iron has not been the result of a series of fortunate accidents, but, on the other hand, has only been accomplished after careful thought, repeated experiments, and adaptation of existing manufacturing methods to meet the requirements necessitated for the production of the

metal desired. Commercially pure iron manufacture does not commence with the open hearth process. Neither is the blast furnace the starting point. It is necessary to go to the source of all ferrous metal production, namely, iron ore.

Since the development of commercially pure iron is

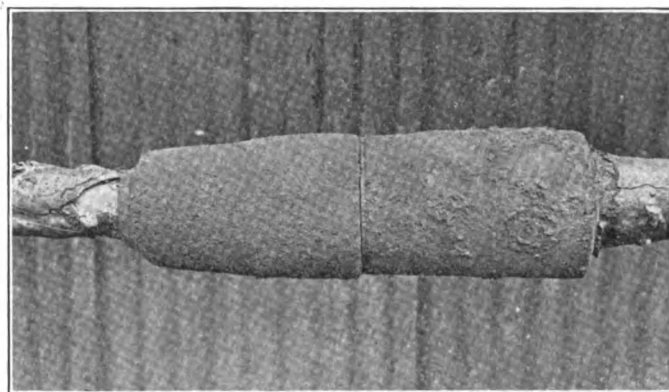


Fig. 1.

a purification process, the choice of the ore is of vital importance. Obviously, the purer the ore, the fewer initial impurities require elimination. It is for this reason that the ore is selected with exacting care and only that of the highest quality is used for the subsequent reduction. When the ore is obtained, the process of commercially pure iron production becomes two-fold; first,

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the efforts necessarily expended in reducing the ore itself; and, second, continuous fighting to keep the product free from contamination due to impurities existing in such raw materials as are required in the purification process.

Using the purest limestones and cokes obtainable, the

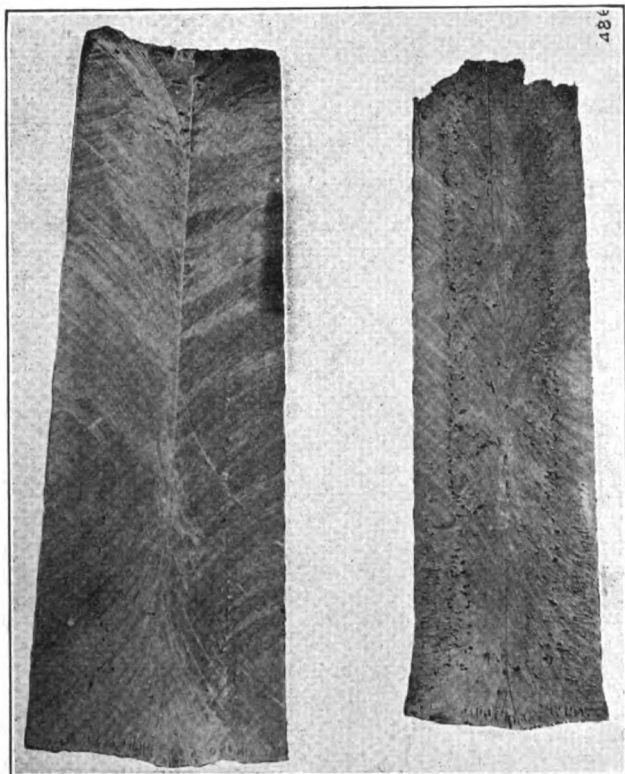


Fig. 2.

high grade ore is reduced in the blast furnace with a result that the contaminating impurities in the pig iron are reduced to a minimum. It is self-evident that the pig iron, scrap, and other raw supplies used when charging the open hearth furnace are not dumped in haphazardly, but are selected only after repeated analytical examinations, comparison of values and elimination of poor quality materials. Even the fuel is analyzed, and, when producer gas is used, each car of coal chosen for gas making purposes must conform to very rigid low sulphur and other quality specifications.

Following the usual basic open hearth process, the charge of selected materials is melted down until the heat is in the usual condition for tapping. At this point, however, there is a radical change from the practice as followed for the production of ordinary irons or steels. Although the molten metal is in condition to tap for the manufacture of these last named metals, yet, commercially pure iron requires additional purification.

The charged limestone having already reduced the sulphur and phosphorus contents to a minimum, pure hematite ore is now added for the purpose of reducing the silicon, carbon, and manganese impurities to such low amounts that the resulting product will contain traces of silicon, sulphur, phosphorus, carbon and manganese in summation of less than two-tenths of one per cent.

Metal tests are taken from the furnace about every 30 minutes during this final additional purification. Ore is added after each test is taken and this procedure is

followed until an analysis of the preliminary sample shows that the above mentioned impurities are reduced to such low amounts that the metal conforms to commercially pure iron specifications, the manganese and carbon contents both being below .02 per cent.

The direct and indirect results attending this purification process are many and of decided importance to the commercially pure iron producer. The fact that the heat remains in the furnace from one to four hours longer than when other products are manufactured not only decreases the tonnage output of the furnace, but also requires that the refractory furnace linings be of such high efficiency that they will withstand the continued action of the molten metal. Before a commercially pure iron heat is charged, the bottom and banks of the furnace must be carefully prepared, using the best refractories money can buy.

It is easy to see, since each heat lies in the furnace a few extra hours, that the fuel costs are greatly increased. Also, the molten iron must be heated to a temperature much higher than that required for steel. This practice not only further increases fuel consumption, but also endangers the furnace itself and materially shortens its service life even though the best grade materials are used for its construction.

The slag formed during a commercially pure iron melt is unusually high in iron oxide content. The following typical analyses show the analytical differences between common steel slags and commercially pure iron slags:

	Commercially Pure Iron	Common Steel
Silica	10.06%	14.84%
Iron Oxide	40.43	18.21
Alumina	2.71	3.77
Calcium Oxide	32.66	45.66
Magnesium Oxide	6.17	8.92
Manganese Oxide	4.21	3.87

The extreme cutting action of this high iron oxide slag (augmented by the fact that an increased tempera-

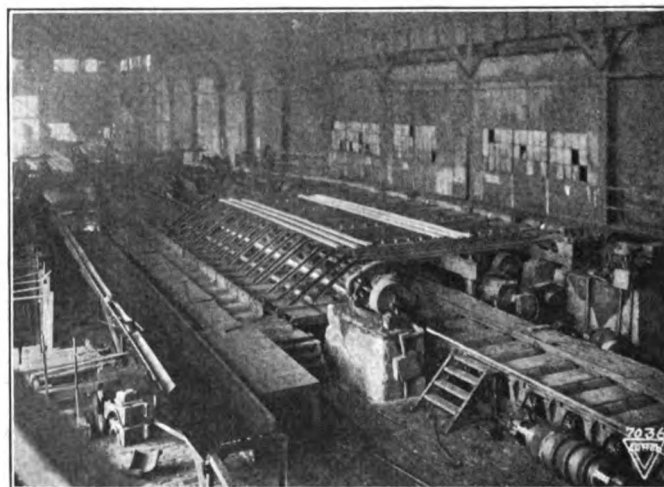


Fig. 3.

ture is necessary that the iron pour properly) plays havoc not only with the furnace linings, but the ladle brick and sleeve brick as well. Using the best grade ladle brick it is necessary to reline the ladle every third or fourth heat, whereas 20 or more steel heats could have been poured without relining.

Fig. No. 1 illustrates this point very clearly. This is the view of a section of a stopper rod actually used when pouring a commercially pure iron heat. Two sections of a costly yet highly refractory brick of special design and quality were placed on the rod in order to compare them with the ordinary sleeve brick which covered the remainder. These sleeves, which the illustration shows have successfully withstood the action of the slag, were developed after many trials and a thorough comparison of various style sand qualities based on results of actual service experiments.

Each step in the manufacture of commercially pure iron has required scientific thought, study and experiment. The efforts of an efficient research organization have been essential factors in the development of the product. Another example typifying the need of research endeavor was the problem of degasification; in other words, the perfection of sound ingots so that, when rolled and fabricated, the metal would be sound and possess the very desirable qualities resulting when the iron is gas free. Fig. No. 2 (split ingots) illustrates how successful the degasification experiments have been and shows the sound commercially pure iron ingot in comparison with the usual unsound condition of the common steel ingot.

When ready to roll commercially pure iron, the manufacturers were confronted with another problem, namely, the fracturing and breaking of the metal when rolled at certain temperatures. Investigation disclosed the fact that commercially pure iron had a critical range within

which it could not be worked. To overcome this rolling characteristic, it was necessary to again depart from usual manufacturing procedures.

The ingots when removed from the soaking pit are worked through the bloomers, cut in suitable lengths, and transferred to cooling racks (Fig. 3) where they cool down through the critical range. They are then removed from the rack, rolled to proper thickness, and sheared into standard sheet bar lengths.

Mention must be made of the skilled inspection to which each bar is subjected before it is declared fit for sheet rolling purposes. Only such bars as are entirely free from blemishes are permitted to pass to the sheet mill units. This step in the manufacturing process insures prime sheets which, after scientifically controlled annealing, are prepared for industrial use by such various finishing processes as are required in order that they conform to the rigid specifications demanded for quality sheets.

These described departures from the usual manufacturing processes do not tell the whole story of commercially pure iron production, yet the examples enumerated typify the procedure necessary to show clearly that each step in the entire production process is the result of careful planning, research investigation, and the elimination of such manufacturing procedures as may be suitable for ordinary iron or steel production but are inadequate when commercially pure iron is the desired product.

The Acid Electric Steel Process

Outline of an Article on This Subject Written by Albert Muller and Published in *Stahl und Eisen*—Various Metallurgical Reactions in This Process Are Recorded.

By R. J. WEITLANER

LOOKING through the technical literature pertaining to the manufacture of steel in the acid electric furnace, we find a great lack of information concerning this important branch of the steel industry. What little has come out in this respect is chiefly devoted to the melting practice, but very little light is thrown upon the various metallurgical reactions taking place in this process.

In view of the fact that the acid electric process plays such an important role in the steel foundry and will perhaps in the future become an adjunct to either the basic electric or basic open hearth, it may be opportune to give to American steel makers the outline of an article on acid electric steel by Albert Mueller as published in *Stahl und Eisen* of Jan. 15, 1914, to be followed later on by a discussion of acid electric melting as practiced in this country, as far as the writer's own experience with it is concerned or as far as it has come under his observation.

The above author deals with the refining of hot metal in a three-ton Girod Furnace, the hot metal was delivered from a basic open hearth or basic converter. He begins with a description of an acid furnace lining.

The hearth of the furnace was made with a mixture consisting of 80 per cent crushed, old silica bricks, 6 per cent fire clay and 14 per cent tar and rammed in as far as the slag lime, the side walls and the roof were made of silica bricks.

TABLE 1.

Composition.	Bottom			Side Walls	
	To start with.	After 27 heats.	After 27 heats.	To start with.	After 27 heats.
SiO ₂	5.72	80.50	64.60	95.30	83.50
CaO	46.50	4.30	12.90	1.85	3.55
MgO	27.60	1.91	2.90	Tr	.65
Al ₂ O ₃	1.46	3.08	2.65	.58	.97
Fe ₂ O ₃	1.85	.38	.43	.57	4.50
Fe O	.99	1.16	1.93	.26	3.65
Mn O	.40	.27	12.05	.19	2.36
P ₂ O ₅	.09	.02	.02	.08	.08
Carbon	8.60	7.75	1.20	Not det.	Not det.
Ignition Loss	14.35	7.80			

Table 1 illustrates the changes taking place in the composition of the hearth and side lining after a run

of 27 heats, and gives for comparison the composition of a basic hearth. One may readily see to what large changes in composition the acid hearth is subjected, especially in regard to its content in silica as well as to CaO , MgO and the oxides of Fe and Mn, showing the marked influence of the reactions in the furnace upon the bottom material.

The carbon left in the hearth from the tar is usually absorbed after two heats, but whereas this carbon in the basic bottom has no part in the chemical reactions it plays a very important role in the acid furnace, reducing SiO_2 to a large extent, so that the first few heats show an excessive amount of silicon in the final product.

Tables 2 and 3 give the changes in the composition of steel and slags, also showing the various additions made during five heats and Figures 1 to 5 illustrate these results by means of curves.

- (3) Reduction of SiO_2 through increase in slag temperature.

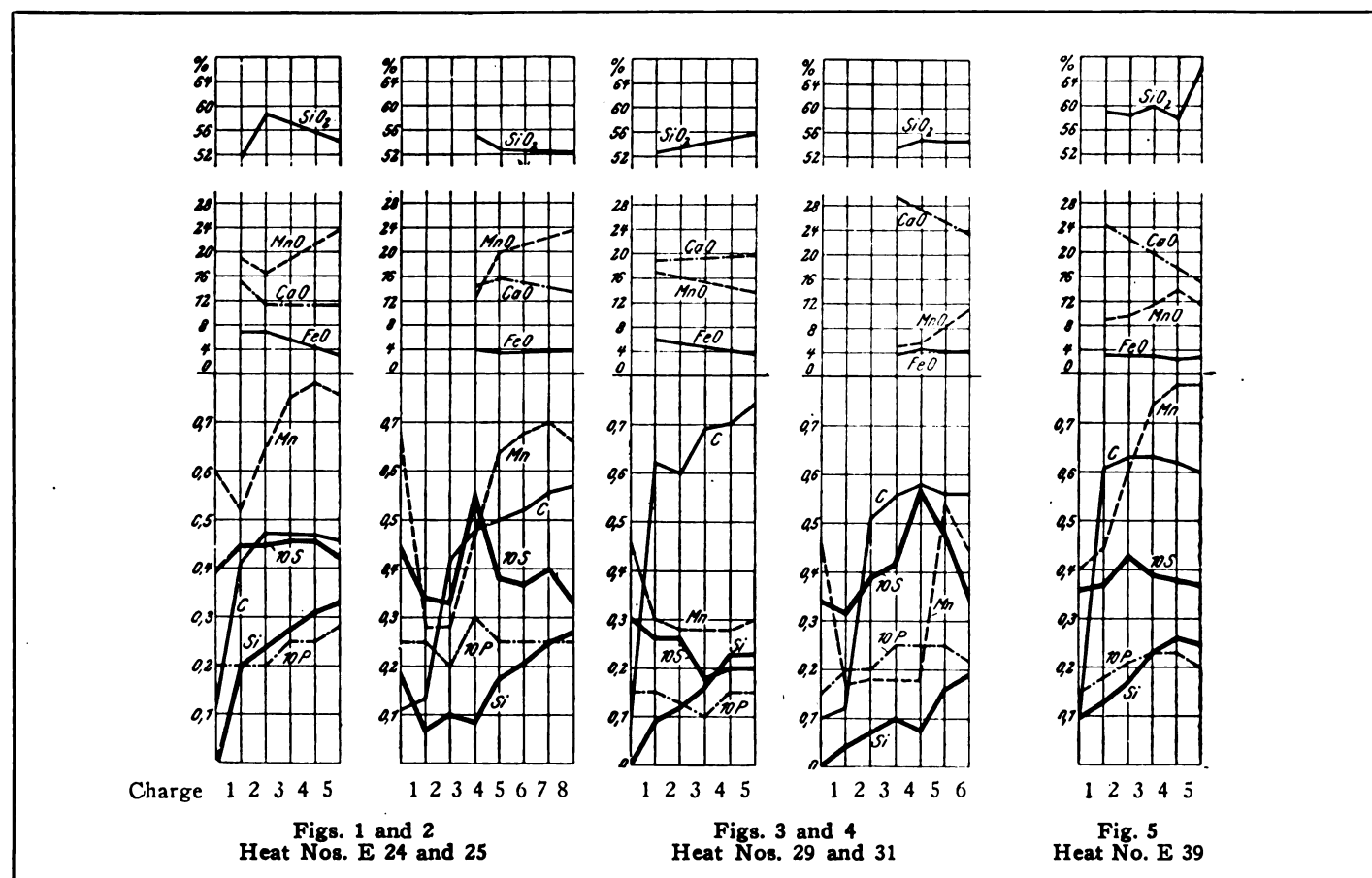
Heat No. 24 shows a decrease of SiO_2 in the slag from 58.8 per cent to 54.4 per cent and a simultaneous increase of Si in steel of .1 per cent due to higher power input and resultant rise in temperature.

- (4) Reduction of SiO_2 by carbon.

According to $\text{SiO}_2 + 2\text{C} = \text{Si} + 2\text{CO}$.

This reduction takes place during carburizing and will be noticed in heat No. 24 where with an increase in carbon of .30 per cent the silicon went up from .0 to .20 per cent.

All these reactions increase in intensity with an increase in temperature of steel and slag. The increase in Si is particularly noticeable in newly lined furnaces but after a longer run this phenomenon becomes less important. As this reduction decreases in



Reduction of Silica.

The examples given in tables and curves allow us to distinguish 4 separate phases of silica reduction, as follows:

- (1) Continuous and almost exclusive reduction of SiO_2 from the hearth.

In a normal run and at normal temperatures the reduction of Si. will largely come from the silica of the hearth. (See heat 25.)

- (1) Reduction of SiO_2 due to increased percentage of SiO_2 in slags.

An addition of silicious material (sand) to the slag results in a sudden increase of Si in the metal as seen from heats 29 and 39 making the slag sticky and pasty.

intensity the two most important reductions are presented by the degree of silicity and the temperature of the slag. We notice that these reactions are proportionately far more intense than similar reactions in an acid open hearth furnace or in the crucible process, whereas only one eighth of the SiO_2 is reduced in the latter.

The reduction of Si from the lining and the slag is the source of certain advantages inherent to the acid electric process one of which is found in the improvement of the quality of the steel and another in the greater economy, since additions of metallic Ferro silicon become unnecessary. It also causes a certain quietness during pouring, which is characteristic of acid electric steel and exerts a very favorable influence

TABLE 2—RESULTS OF HEATS.

Practice.	Test No.	C.	Mn.	P.	S.	Si.
Open Hearth metal 324.....		.12	.60	.020	.040	trace
40 lbs. petrol coke	1	.42	.52	.020	.045	.20
22.4 lbs. Ferro-manganese	2	.47	.64	.020	.045	.24
26.9 lbs. Ferro-manganese	3	.47	.75	.025	.046	.28
	4	.47	.78	.025	.046	.31
Final anal. of heat 24.....	5	.46	.76	.028	.043	.33
Open Hearth metal 330.....		.11	.66	.025	.044	.18
44.8 lbs. ore, slagged off.....	1	.13	.28	.025	.034	.07
44.8 lbs. petrol coke and electrodes.....	2	.42	.28	.020	.033	.10
44.8 lbs. Ferro-manganese	3	.48	.40	.030	.053	.09
22.4 lbs. Ferro-manganese	4	.50	.64	.025	.038	.18
6.7 lbs. Ferro-manganese	5	.52	.68	.025	.037	.21
	6	.56	.70	.025	.040	.25
Final anal. of heat 25.....	7	.57	.66	.025	.034	.27
Open Hearth metal 360.....		.09	.46	.015	.030	trace
62.7 lbs. petrol coke.....	1	.62	.30	.015	.026	.09
3 shovels of sand.....	2	.60	.28	.013	.026	.12
Petrol coke to reduce.....	3	.69	.28	.010	.018	.16
MnO in slag.....	4	.70	.28	.015	.020	.23
Final anal. heat 29.....	5	.74	.30	.015	.020	.23
Open Hearth metal 383.....		.10	.45	.015	.034	trace
134 lbs. ore, slagged off.....	1	.12	.17	.020	.032	.04
49 lbs. petrol coke and electrodes.....	2	.51	.18	.020	.039	.07
Test red short.....	3	.56	.18	.025	.042	.10
Test red short.....	4	.58	.18	.025	.057	.08
44.8 lbs. Ferro-manganese.....	5	.56	.54	.025	.048	.16
Final anal. of heat 31.....	6	.56	.44	.022	.035	.19
Open Hearth metal ?		.09	.40	.015	.036	.10
54 lbs. petrol coke	1	.61	.44	.018	.037	.13
22.4 lbs. Fe Mang	2	.63	.60	.021	.043	.17
33.6 lbs. Fe Mang—3 shovels sand.....	3	.63	.74	.023	.039	.23
4 shovels sand	4	.62	.78	.023	.038	.26
Final anal. of heat 39.....	5	.60	.78	.020	.037	.25

TABLE 3—CORRESPONDING SLAG ANALYSIS.

Heat No.	Test No.	SiO ₂	CaO	MgO	Al ₂ O ₃	Fe ₂ O ₃	FeO	MnO	S	P ₂ O ₅	O in base O in acid
24	I	51.50	15.30	3.80	2.60	...	6.95	18.85	.25	.01	
	II	58.80	11.40	4.30	2.14	...	6.85	16.30	.27	.03	
	V	54.00	11.50	5.20	1.72	...	3.35	23.55	.29	.03	
Oxidiz slag 25		39.02	5.80	1.50	1.92	2.15	23.80	25.41	.15	.20	
	III	54.84	14.50	...	...	...	3.85	12.66	.20	...	
	V	52.70	15.80	...	...	...	3.60	20.15	.12	...	
	VII	52.60	13.70	3.20	1.52	...	3.85	23.70	.13	.12	
29	I	52.50	18.75	2.90	1.36	...	5.80	16.70	.11	.05	
	V	55.80	19.60	4.02	2.02	...	3.55	13.85	.03	.03	1/3
Oxidiz slag 31		45.10	5.35	2.10	1.75	2.30	23.65	19.30	.40	trace	1/2
	III	53.50	29.60	3.10	1.49	.43	3.60	4.95	.37	trace	
	IV	55.20	not det.	...	...	...	4.35	5.70	..	..	
	V	54.20	not det.	...	...	...	4.25	8.35	..	..	
	VI	54.20	23.20	3.05	1.86	.35	4.05	11.15	.40	trace	2/3
39	I	58.83	24.29	2.40	1.75	.29	3.07	8.93	.39	trace	
	II	58.54	not det.	...	...	...	2.96	9.59	..	..	
	III	59.78	not det.	...	...	...	3.08	11.45	..	..	
	IV	57.92	not det.	...	...	...	2.58	13.79	..	..	
	V	66.27	15.26	2.03	.15	...	2.81	11.68	.51	..	1/4

upon the micro structure and grain size of the finished product.

According to Thallner, Geilenkirchen & Eilender, the continuous action of reduced silicon upon the metal must need be preferable to the addition of silicon in its solid state, as it is not liable to leave behind products of oxydation, in the form of silicates of iron and manganese which may not have time to rise to the surface and are liable to make their appearance in the final product as sand spots, etc. The action of silicon in its nascent state as we may say, will naturally be more beneficial in destroying oxides, emulsions and gases than solid silicon.

Sulphur.

Besides the various reactions of silicon in the acid electric process, the next important element to be considered is the sulphur.

A glance at the heat curves and charts reveals the interesting fact that in almost all these heats the sulphur shows a marked variation throughout the operation finally resulting in a slight decrease.

If we first consider the oxydizing stage of a melt we will note a slight decrease in sulphur which is most probably caused by the reaction $\text{FeS} + 2 \text{FeO} = 3 \text{Fe} + \text{SO}_2$.

This oxydation of S to SO_2 also occurs in the puddle process and in the oxydizing stage of the basic elec-

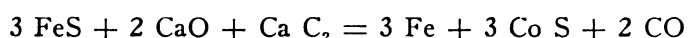
tric furnace. This is particularly manifest in heat No. 25 and to a minor degree in other cases where the FeO content of the slag was less marked and where the temperature was possibly lower. Considering now the second, or refining part of the process another explanation must be sought to account for the fact that the percentage of sulphur in the metal is not only maintained but in some cases decreased.

It should be borne in mind that in adding petrol coke considerable quantities of sulphur (see heats Nos. 25 and 31) were introduced into the metal and as the tests taken did not correspond in time with these additions, the apex of the sulphur line would be considerably higher than the one shown by the curves (see Figs. 2 and 4). The actual amount of sulphur contained in 62.7 lbs. of petrol coke added in heat No. 29 was 170 grams, corresponding to .01 per cent S in the bath, most of which must have been dissolved by the steel and then again been eliminated in the course of the melt.

We are therefore justified to speak of a desulphurization in the acid electric furnace.

How does desulphurization in an acid electric furnace take place?

In the basic electric process desulphurization is carried out under a strongly basic and reducing slag after all the oxides of iron and manganese have been reduced according to:



We are not only able to obtain slags in the acid furnace which are practically free from oxides but may even observe the formation of calciumcarbide from the lime and carbon added.

On account of the low percentage of lime however and the presence of considerable MnO in these acid slags we cannot speak of a desulphurization according to above equation. This is shown by the fact that the CaS content of the slag is not appreciably higher in the final slag test. Therefore we must conclude that sulphur is reduced thru formation of the volatile sulphur silicide SiS_2 , a reaction which also occurs under the electric arc of the basic electric process.

In regard to the elimination of phosphorus which can be carried out so completely under a basic oxydizing slag in the basic electric furnace, this of course cannot be done in the acid process. Any phosphates of iron would be decomposed by the excess of silica, the phosphorus being reduced back into the bath. Curves 1 to 5 show a slight increase of this element due to metallic additions made at the finish of the heat.

Furnace Practice.

In conformity with the acid lining an acid slag has to be carried, which, with a cold charge will form itself through combination of iron and manganese oxides with the impurities of the charge and through oxidation of silicon. As the furnace in discussion, however, was always charged with hot metal, additions of silicious material were necessary to cover the bare bath.

We can, like in basic process distinguish between oxydizing and reducing slags the former being the iron-manganese silicate slag, has great similarity with the corresponding slag of an acid open hearth, whereas the latter is peculiar to the acid electric furnace only.

Looking at the composition of two oxydizing slags

(heats 25 and 31) we note that on account of a greater basicity of the slag in heat 25 a greater destruction of the hearth will and actually did take place. It is therefore advisable to work towards a more silicious slag of lower MnO percentage as shown in heat No. 31. After removal of the oxydizing slag, a practice which is only required for certain grades of steel the reducing slag mixture consisting of 75 per cent crushed silica bricks and 25 per cent burned lime is thrown on which melts quickly without any addition of fluxes.

As seen from analyses the composition of the acid slag varies considerably and is subjected to great changes during the ensuing melting.

Special care has to be taken in the regulation of these slags in order to obtain the proper finishing slag necessary for a satisfactory material.

The degree of heat has, according to Thallner, a decisive influence upon the slag.

With the low temperature, at the beginning of de-oxidation we obtain mostly dark gray or more or less glassy slags on account of high iron oxide content. With increasing temperatures however, the color of the slag turns lighter, becomes porous and finally liquid. With the beginning reduction of iron oxides and a corresponding increase in MnO the glassy mass turns into a light gray. According to various percentages of MnO we obtain green slags of all shades. With a higher lime content for instance 30 per cent CaO, 5 per cent MnO, 54 per cent SiO_2 and 4 per cent FeO the slags appear gray and even desintegrate when exposed to air. Those that contain 55 per cent SiO_2 , 32 per cent CaO, 8 per cent MnO and 2 per cent FeO are of a blue color and reveal, when fractured, a structure similar to volcanic lava. These various intermediate slag stages can, with proper addition and temperature regulation be converted into a liquid, greenish-yellow finishing slag, under which the refining and settling of the bath is to be carried out.

The fact that on the one hand basic constituents of an acid slag react destructively upon the lining but that on the other hand a highly silicious slag remains too viscous, requires a certain basicity of the slag. While oxydizing acid slags show a ratio of 1:2 for the oxygen in the bases to the oxygen in the acid constituents, we may have as high a ratio as 1:4 for reducing conditions (see heat 39). This is however unusual and only permissible for certain grades of steel and it is therefore desirable to decrease the oxygen in the acid resulting in a lowering of its melting point. The means to obtain these conditions are additions of lime and magnesia.

The percentage of lime is best kept around 15 per cent, as 20 per cent in the slag acts deteriorating upon the lining. An increase in Magnesia also increases the basicity and liquidity of the slag. MgO content should be between 2 per cent and 5 per cent. It is advisable to keep the magnesia down to this percentage and to regulate the basicity of slags by means of MnO. This can easily be done by addition of crushed Ferro-manganese as seen in heat 39. A further increase of MnO above 10 to 15 per cent may result in throwing back of manganese into the bath through reducing agents like coke, etc. Such was the case in heats 29 and 39 where the addition of a shovel of petrol coke reduced 2.85 per cent and 2.11 per cent MnO in a very short time.

The presence of such percentages of MnO are characteristic of a reducing acid electric furnace slag in

comparison to basic reducing slags in which the MnO content is practically nil. Less difficult than the reduction of MnO is that of iron oxide, its percentage being much lower than that found in acid open hearth slags and forming another characteristic of an acid deoxidizing practice. The iron oxide content varies usually between 7 and 2 per cent being higher at the beginning of the reducing period and can easily be decreased through addition of free carbon.

The reduction of FeO in the slag is partly caused by the continuous action of the electrode carbon upon the slag, its percentage usually coming down to between 3 or 4 per cent.

A further reduction of FeO is obtained by adding carbonaceous material such as coke and can be carried out to an extent practically equal to that of a final basic slag (see final slag of heat 39). No particular advantages could however be gained.

When comparing these final slags with those of the acid open hearth, in which the SiO₂ remains close to 50 per cent and very rarely exceeds 55 per cent we note, that in "acid electric furnace melting" the SiO₂ is generally between 55 to 60 per cent.

Should however the SiO₂ increase any further we obtain slags of high melting point, as seen in heats 39 with 66 per cent. SiO₂ requiring addition of fluxes to thin out and to restore their capacity for reactions. It is therefore best to regulate the slags so as to obtain a ratio of basicity of 1:3.

The author in conclusion favors the adoption of the acid electric furnace process in preference to the basic, in such steel plants where hot metal of reasonably low percentage in S. & P. is available and where the final product comes within specified requirements in these elements. During a long run in this particular steel plant, and without particular care in the selection of open hearth charges, the average phosphorous content of the acid electric heats was .020 per cent and the sulphur showed an average of .035 per cent.

These low percentages of S. & P. have of course no harmful effect upon the physical properties of the steel. Of greater importance upon the quality of the product is the care during melting and finishing of the heats, the proper slag conditions and temperatures of the bath which exert a decisive influence upon the micro structure of the steel. The temperature during refining has according to Thallner, a marked influence upon the crystalline structure and hence upon the shaped product.

Proper melting and refining in the acid furnace is however not as easy as may perhaps be imagined, requiring technical ability and experience as well as metallurgical knowledge. The desirable formation of silicon in its nascent state does not constitute in itself a superiority over other processes. The author summarizes the economical advantages offered by this process when compared with the basic process as follows:

- (1) Less current consumption due to shorter melting time. The duration of a heat is shortened as the oxidizing period is in most cases eliminated. The deoxidizing period, being continuous and intenser in degree than in the basic process, can therefore be carried through in a shorter time.
- (2) Saving in deoxidizers, the silicon being obtained from lining and slag as outlined before.

- (3) Less lining, repair and maintenance cost, on account of the lower price of the acid material when compared with basic refractories, such as magnesite, etc.
- (4) The cost for furnace additions in the acid furnace are almost nil, as the final slags can, with advantage be used over again.

Resume.

The acid electric furnace process offers economical as well as metallurgical advantages to such steel works which have at their disposal a metal low enough in phosphorus and sulphur to come within given specifications. The process is also limited by the silicon reactions resulting in a silicon content unsuitable for certain grades of steel.

Appendix.

In addition to the article by the above writer, I may quote O. Thallner, *Stahl und Eisen*, 1910, p. 1348, who predicts that in the near future it will be possible to eliminate sulphur more thoroughly in the acid electric furnace.

Eilender in *Stahl und Eisen*, 1913, p. 585, presents curves, showing a much lower power consumption for the acid than for the basic electric furnaces. The greater intensity of the reactions and the lower heat conductivity of acid refractories is given in explanation of this fact. The quality of the steel is said to be mainly dependent upon the size of the molecules in the molten stage, the smaller the latter the better the quality of the steel. Even for best grades higher sulphur and phosphorous limits are allowable.

THE FATIGUE OF METALS.

Professor H. F. Moore addressed, probably one hundred members of the Pittsburgh Chapter of the American Society for Steel Treating on the evening of December 6, at the Hotel Chatham, on the subject of his recent investigation, "The Fatigue of Metals." His discussion was so beautifully clear and concise, so nicely interspersed with every day examples of the thought he wished to express, that we cannot do otherwise than imagine that his ability to present an easily understood story to his audience has been acquired by much experience in teaching.

As his report will be distributed in bulletin form by the University of Illinois in the near future, attempt to set forth here any part of his address would be useless other than to say that he found in the tests which they have made that the Brinnell hardness might be used in predicting the approximate value of the endurance limit. The other physical properties apparently bear no relation to the endurance limit with the possible exception of the ultimate strength. Prof. Moore does not attempt to explain this apparent relationship or lack of relationship. We admire his frankness in admitting inability to account for this proportionality. This absolute candidness coupled with his lucid explanation of the tests conducted and his discussion of the results obtained combined to make the evening most profitable.

The next meeting of the Pittsburgh Chapter will be addressed by Prof. A. E. White of the University of Michigan and past-president of the American Society for Steel Treating.

Open Hearth Furnace Makes a Record

McKune System Furnace Installed at the South Works of the Illinois Steel Company Shows Remarkable Speed and Efficiency.

THE McCUNE type of furnace has worked a radical change in the construction and operation of Open Hearth Furnaces. Remarkable results have been obtained in increased production per furnace unit and decreased cost of operation per ton of product.

In making a comparison between the construction and operation of the ordinary Open Hearth Furnace as compared to one of the McKune type, we find that in the ordinary construction the furnace ports are necessarily built of large area to provide for the exhaust of the waste gases of the furnace. Such large port areas are contrary to the requirements of the incoming air and fuel. To obtain a rapid mixture of the air and fuel and therefore the best combustion, much smaller areas should be used. Because of the large port areas necessarily used in the furnace construction for ex-

ing port and a large outgoing port. The method of operation is to provide a high velocity to the incoming air so as to drive it into quick mixture with the fuel in order to obtain a rapid combustion similar to that of the blow-torch flame, and a flame well directed onto the materials being heated and melted, and to exhaust the waste gases at a low velocity through the outgoing port. A fan is used to force the air supply through the restricted port area. Mr. McKune perfected this method of operation in the winter of 1919 and 1920, obtaining a large increase in production per furnace with a corresponding decrease in the amount of fuel used per ton of product. Because the flame was well-directed to the furnace charge and away from the furnace walls and roof and on account of the low velocity of the outgoing gases, the life of the furnace was very

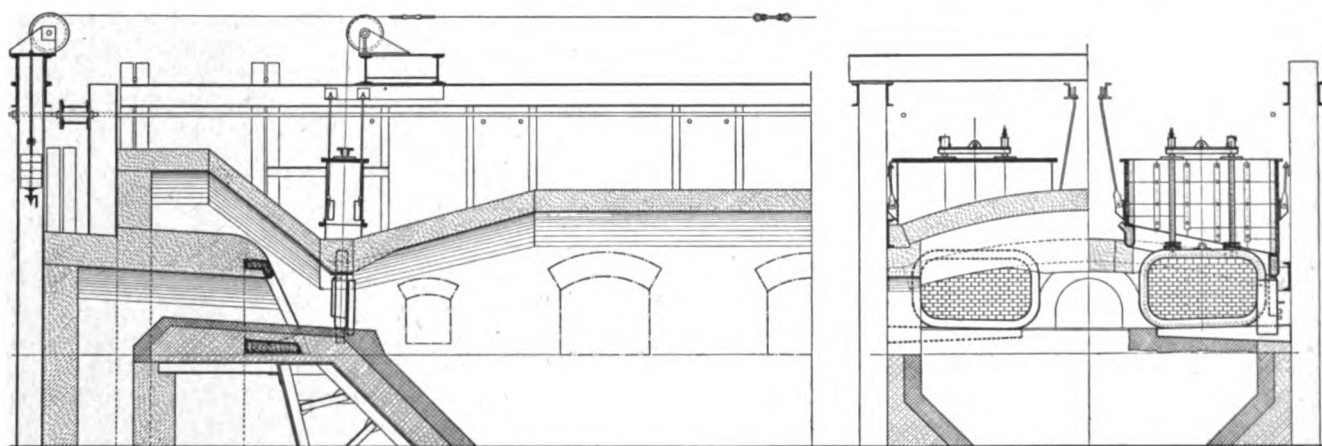


Fig. 1—Section through McKune furnace.

haust purposes, the Open Hearth operator in the past has failed to realize the much higher efficiency obtainable through a more rapid mixture of the air and fuel, coincident with the use of small port areas.

The McKune type of furnace was first developed at the Steel Company of Canada, Limited, by Mr. F. B. McKune, Open Hearth Superintendent. At this plant a by-product coke installation was put into operation in 1919, and because of the high price of other fuels it was highly desirable to use the surplus coke oven gas as fuel for the Open Hearth. Wherever coke oven gas had previously been adopted as Open Hearth fuel, it was in combination with liquid fuel, such as oil or tar, the high velocity of the atomized liquid fuel being used to control the very light coke oven gas. The use of coke oven gas alone had, after numerous trials, been given up as impractical. At the Steel Company of Canada the use of debenzolized coke oven gas became a necessity, which resulted in the conception and development of the McKune type of furnace.

The governing principle of the McKune construction is to provide the means of having a small incom-

much prolonged and the cost of the furnace maintenance reduced. These results soon became generally known and attracted the attention and interest of progressive Open Hearth managements. They have come to realize that in order to obtain the maximum production and economy, the Open Hearth port construction and operating methods of the past must give way to new construction and operation.

With the port areas controlled by the damper arrangement as devised and developed by Mr. McKune for coke oven gas, natural gas or liquid fuel can be equally well utilized with the same improvement in production and economy compared to past practice. Inasmuch as the greater number of Open Hearth furnaces are operated with producer gas an equivalent arrangement was necessary to be developed for this fuel. In the past construction of Open Hearth furnaces the use of producer gas has entailed a more complicated port construction compared to that necessary for the other fuels and it was not an easy matter to develop the application of the McKune principle for producer gas without complicating the port design.

However, George L. Danforth, Jr., and his associates have developed a port construction and controlling damper arrangement as simple, effective and durable as for the other fuels. Furthermore, with this adaptation any fuel can be used equally as well by simply providing an ordinary means of supplying the other kinds of fuel to the port used for the introduction of the producer gas. When fuel other than producer gas is being used with this arrangement, the gas generators and passageways would be used for the introduction of approximately one-half of the air supply.

As shown by Figure 1, two dampers are used on each end of the furnace. On the incoming end of the furnace the two dampers are lowered into the port area several feet in front of the gas port mouth, providing a central passageway approximately one-third of the total throat area. This small area makes it possible to obtain a comparatively high velocity to the air which drives it into a more rapid mixture and combustion of the fuel, providing a much shorter and hotter flame than it is possible to otherwise obtain. The dampers on the incoming end are counterbalanced by means of sheaves and cables with those of the outgoing end which are drawn up through the low roof knuckle into a brick lined box, leaving the total area of the throat available for the waste gases exhausted at a low velocity. This provides a better passageway for the outgoing gases than provided for in the port of an ordinary type of furnace, as there is no block for the outgoing gases to pass over and make a hairpin turn down the downtakes.

The low knuckle of the roof coupled with the absence of any port block keeps the waste gases traveling across the melting chamber at a lower elevation, and in better contact with the bath. With this arrangement, as compared to that of an ordinary furnace there is obtained a material improvement both to the incoming and outgoing end of the furnace, resulting in a much faster and more efficient transfer of heat to the materials being treated. Because of the comparatively short flame with its better direction, the life of the entire furnace brickwork is materially prolonged.

A producer gas furnace as just described was installed at the South Works of the Illinois Steel Company about July 1, 1921. After a few days of operation, required for properly adjusting the air supply and other operating devices of the new arrangement, the furnace began to show remarkable speed and efficiency. The hearth dimensions of this furnace are as follows:

32 feet long by 13 feet 3 inches wide, giving a hearth area of 424 square feet, equivalent to that of an ordinary fifty-ton furnace.

There was produced in this furnace in the month of August, 1921, 105—76.5-ton heats for a total of 8,020 gross tons with 400 pounds of coal per ton of ingots. In a later period of thirty-one days, there was produced 106—85.5-ton heats for a total of 9,053 tons, with 348 pounds of coal. In the three-month period, August 1st to November 1st, the furnace was operated 85½ days and made 268—80.8-ton heats for a total of 21,670 tons, with 413 pounds of coal. A straight Open Hearth charge of 50.8 per cent hot metal 43.8 per cent scrap and 5.4 per cent metals from ores was used. This is by far the most remarkable performance ever accomplished on an Open Hearth furnace and the tonnage from this 50-ton hearth is believed to be considerably more than was ever produced on much larger furnaces for any equivalent period of time.

Mention has been made of the comparatively long life of the furnace. At the time of writing this article, the furnace is still in operation, having produced 417 heats for a total production of 33,000 tons. Experience with this furnace has shown that the operation in the latter part of the furnace life will be more equal to that of the first part than is true with the past construction, for the dampers maintain the correct area of the incoming port throughout the campaign and on account of the comparatively short flame and the low velocity of the outgoing waste gases, the furnace checker work remains much freer of deposit and the furnace draft is correspondingly improved over that of the ordinary type. Although having produced over 33,000 tons of steel, the furnace is still producing approximately 1350 tons of steel per week which is beyond the possibilities of the average Open Hearth furnace even when new and at its best.

The following table conservatively exhibits the relative production and cost of operation of this type of furnace compared to the ordinary type:

	Ordinary Type.	McKune Type.
Representative Hearth Area....	500 sq. ft.	500 sq. ft.
Representative Size of Heat....	80 tons	80 tons
Maximum Production per Month	6,000 tons	9,000 tons
Average Production per Year...	48,500 tons	72,750 tons
Excess Production per Year		24,250 tons
Cost of Operation per Ton.....	\$4.50	\$ 3.50
Annual Savings at \$1.00 per Ton		72,750.00
Subtract First Cost of Equipment		12,000.00
Net Saving First Year.....		60,750.00

The excess production of 24,250 tons per year would otherwise have to be provided by additional installation at an approximate cost of \$200,000.00.

It can be readily understood that in addition to the large savings made in the cost of operation, the large production per furnace unit provides a great saving in the cost of installation per ton of product. Steel companies from time to time find it necessary to provide more Open Hearth producing capacity. This increase has been made in the past by providing more furnace units at a capital expenditure ranging from \$7.00 to \$10.00 per ton of annual capacity. A large increase in capacity can now be met by reconstructing the present furnaces to the McKune type, at a very nominal cost.

Open Hearth operators realize that with the hotter, faster-working furnace and the better control of the flame, a higher grade of steel is produced. The steel made during the record performance of the aforesaid furnace was applied to high grade orders such as seamless tube rounds, fire-box plate, and the general run of mill orders. A great many visiting Open Hearth men interested in the operation of this type of furnace were present during some part of the time in which the records given above were made, and were naturally interested in seeing the finished production of the steel from this furnace. They stated without exception that it was above the general run of Open Hearth product.

The governing principles employed in the McKune furnace and the several specific arrangements for utilizing these principles, are fully protected by patents either issued or pending. These patents are owned by the Miami Metals Company, of Chicago, Illinois, The Blaw-Knox Company, of Pittsburgh, Pa., have been made their sales agents for McKune furnace installations.

Graphical Treatment of Stack Gas Analysis and Fuel Gas Analysis

Charts Calculated for Stack Gas Analysis for Producer Gas, Natural Gas, By-Product Tar, Coke Oven Gas, and for Coal—Wa. Ostwald Introduced These Graphic Charts.

By W. TRINKS

TO ANYONE but a chemist, there seems to be a more or less deep mystery connected with a stack gas analysis or with a producer gas analysis. The mystery deepens, if calculations are required for checking an analysis for accuracy or for finding excess or deficiency of air.

These conditions, which seem to be the same the world over, prompted Wa. Ostwald, the well known German chemist, to devise methods for graphically representing the relations between the various factors of the products of combustion of hydrocarbons. The results of his efforts are laid down in a little book called "Beitrage zur graphischen Feuerungstechnik" (Notes on graphical Combustion Engineering) which was published by Otto Spamer, Leipzig, in 1920.* In this work, Ostwald spreads himself from flue gas analysis to a graphical theory of the gasification in the gas producer, and even gives a graphical system of all hydrocarbons.

The book has been very fruitful. The ideas of Ostwald were taken up by others and were amplified and enlarged upon in articles which have appeared in the "Zeitschrift des Vereins Deutscher Ingenieure," "Stahl und Eisen," and in "Feuerungstechnik."

As far as the author knows, Ostwald's efforts are not well known in English speaking countries. For that reason, the most important phases of the work are given in the present contribution.

(1) Flue Gas or Stack Gas Analysis.

This part of the article follows, in the main, the derivations given by Mr. Seufert in the Z. d. V. D. I. 1920, page 505.

The purpose of any flue gas analysis is to show a) the carbon-dioxide (CO_2) content, b) the oxygen (O_2) content, c) the carbon-monoxide (CO) content, and d) the excess or deficiency of air. The use of the term "excess air" leads to cumbersome equations. For that reason, Ostwald prefers the air ratio n , which equals the ratio of the theoretical volume of air to the volume of air actually used.

If the composition of the fuel is known, any two of the four values a), b), c) or d) determine the other two. All four quantities can be shown in a triangle by the use of two superimposed systems of coordinates, or they can be represented in an alignment chart. Only the triangle method will be given in this article. The facts underlying the calculations for the construction of the triangle will now be given.

*This book may be obtained from G. E. Stechert & Co., 151 West 25th St., New York City.

I. Method for Solid and Liquid Fuels.

The calculations are simplified by considering carbon to be in the gaseous state, and computing its specific volume from the relation: Molecular weight $\times$ specific volume = a constant, which is called the volume of one mol. Molecular weight of air = 29; specific volume of air at 32 deg. F. and 30" barometer = 12.4; $29 \times 12.4 = 360$; molecular weight of carbon = $2 \times 12 = 24$; equivalent specific volume of carbon $= \frac{360}{24} = 15$ cubic feet per pound.

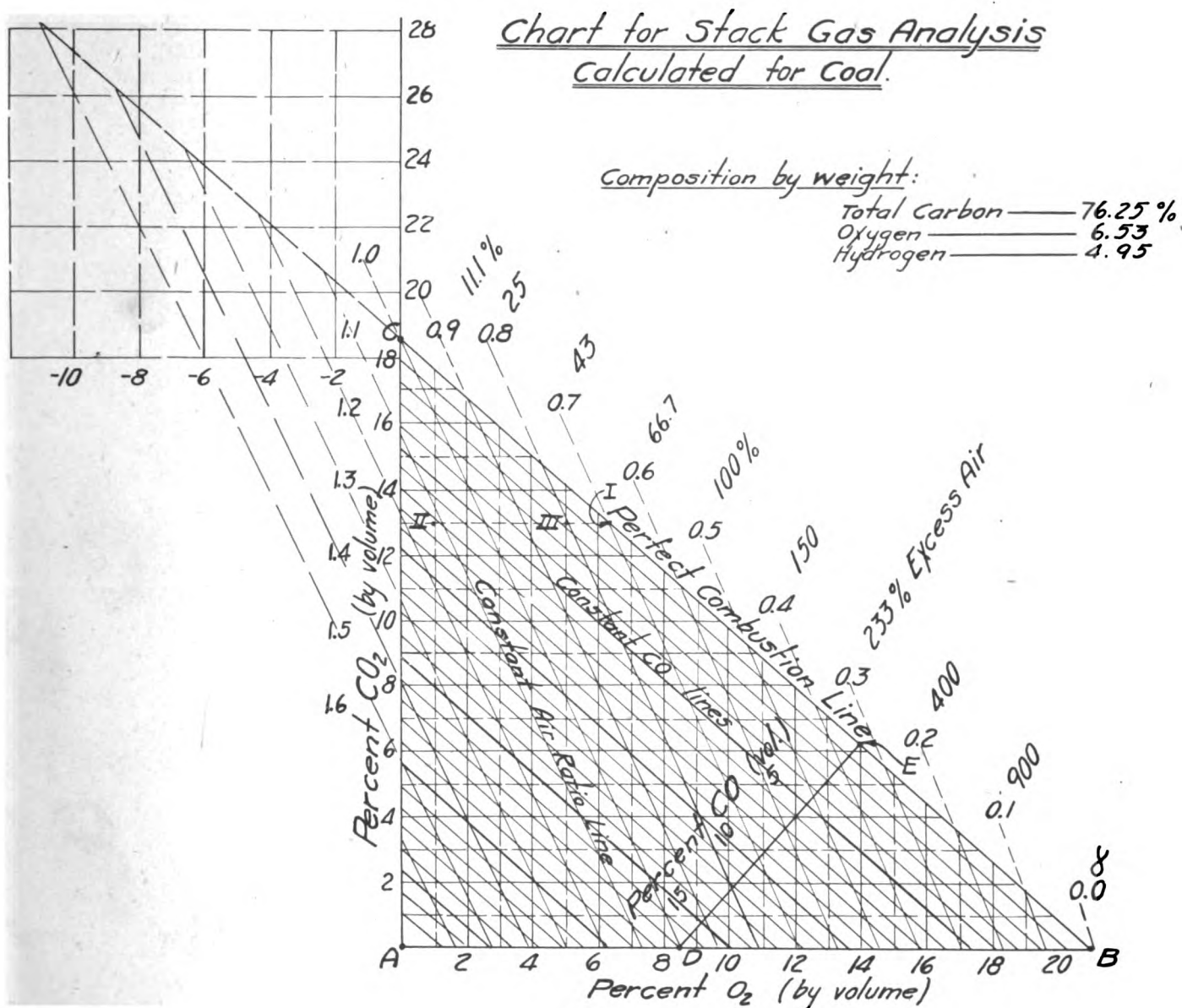
Let one pound of fuel contain c_1 pounds of carbon (C), h_1 pounds of hydrogen (H), q_1 pounds of oxygen (O). Then it contains $h_1' = (h_1 - q_1/8)$ pounds of available hydrogen. (Of the total hydrogen, a part is considered as combined with 8 times its own weight of oxygen, already present in the fuel—hence it does not require any oxygen from the air to burn it.) Sulphur and nitrogen in the fuel have no effect upon the gas analysis, and are, therefore, neglected.

a) Reactions for complete combustion without formation of carbon monoxide (CO).

Water vapor is not considered, because it disappears in the dry stack gas analysis. It should be kept in mind that the stack gas analysis is a **volume analysis**, whereas the analysis of solid and liquid fuels is a weight analysis; also that the volumes calculated are **equivalent** volumes, which the gases would have at 32 deg. F. and 30" barometer, if they were perfect gases following the law: absolute pressure $\times$ volume = constant $\times$ absolute temperature. As water vapor, the only product of combustion which departs far from this law, disappears in the analysis, this procedure is correct.

- 1) $\text{C}_2 + 2\text{O}_2 = 2\text{CO}_2$, which means that
 - 1 (equivalent) cu. ft. C_2 requires 2 cu. ft. O_2 , and produces 2 cu. ft. CO_2 .
 - 1 pound of C_2 requires 2×15 cu. ft. O_2 , and produces 2×15 cu. ft. CO_2 .
 - c_1 pounds C_2 require $30c_1$ cu. ft. O_2 , and produce $30c_1$ cu. ft. CO_2 .
- 2) $2\text{H}_2 + \text{O}_2 = 2\text{H}_2\text{O}$, which means that
 - 1 cu. ft. H_2 requires .5 cu. ft. O_2 .
 - 1 pound H_2 requires $.5 \times 178$ cu. ft. O_2 .
 - h_1 pounds H_2 require $89 h_1$ cu. ft. O_2 .

Hence, theoretical volume of O_2 for 1 pound of fuel = $\text{O}_{\text{mtn}} = (30 c_1 + 89 h_1)$ cu. ft. Actual volume of oxygen, O_a , when the air ratio is n , (from $\text{O}_{\text{mtn}} : \text{O}_a = n : 1$), is $\text{O}_a = \frac{1}{n} \text{O}_{\text{mtn}}$. But each volume of oxygen


$$= \frac{30 c_1 \times 100}{30 c_1 + \frac{79}{21} \times \frac{1}{n} \times O_{\min} + \frac{1}{n} O_{\min} - O_{\min}}$$

$$= \frac{3000 c_1}{30 c_1 + O_{\min} (\frac{4.76}{n} - 1)}$$

- 1) * * * $C_2 + O_2 = 2 CO$, which means that
 1 (equivalent) cu. ft. C_2 requires 1 cu. ft. O_2 , and
 produces 2 cu. ft. CO .
 1 pound C_2 requires 15 cu. ft. O_2 , and produces
 2×15 cu. ft. CO .
 c_1 pounds C_2 require $15 c_1$ cu. ft. O_2 , and " $30 c_1$
 cu. ft. CO .
- 2) * * * Combustion of hydrogen is the same as
 in (a 2).

The theoretical volume of oxygen for incomplete combustion of one pound of fuel is $O'_{min} = 15 c_1 + 89 h_1$, and actual oxygen volume $O_a = \frac{1}{n} O_{min}$, as before. The stack gas volume for one pound of fuel then is $[CO = 30 \frac{c_1}{79} = p$ per cent of dry stack gas volume] + $[N_2 = \frac{79}{21} \frac{1}{n} O_{min}] + [O_2 = \frac{1}{n} O_{min} - O'_{min} = q$ per cent of gas volume].

CO content = $p =$

$$\frac{30 c_1 \times 100}{30 c_1 + \frac{79}{21} \frac{1}{n} O_{min} + \frac{1}{n} O_{min} - O'_{min}}$$

$$= \frac{3000 c_1}{30 c_1 + \frac{4.76}{n} O_{min} - O'_{min}}$$

O₂ content = $q =$

$$\frac{(\frac{1}{n} O_{min} - O'_{min}) \times 100}{30 c_1 + \frac{4.76}{n} O_{min} - O'_{min}}$$

Calculation of q with the before-used values of n furnishes the points on the axis of abscissae AB, Fig. 1; (no CO₂, all carbon burned to CO). Those points of AB and of CD which belong to equal values of n furnish the lines of equal air ratios. The CO division is preferably marked on the line DE, which is drawn perpendicular to CB, passing through that O₂ point of line AB, for which $n = 1$.

A numerical example will make the method clearer. Let the fuel be Pittsburgh coal of the analysis:

Total carbon 76.25 per cent
Oxygen 6.53 per cent
Hydrogen 4.95 per cent

(a) Complete combustion—calculation for points on line CB.

CO₂ content = $k =$

$$\frac{3000 c_1}{30 c_1 + O_{min} (\frac{4.76}{n} - 1)} \quad \text{from above.}$$

$c_1 = .7625$.

Chart for Stack Gas Analysis Calculated for By-product Tar

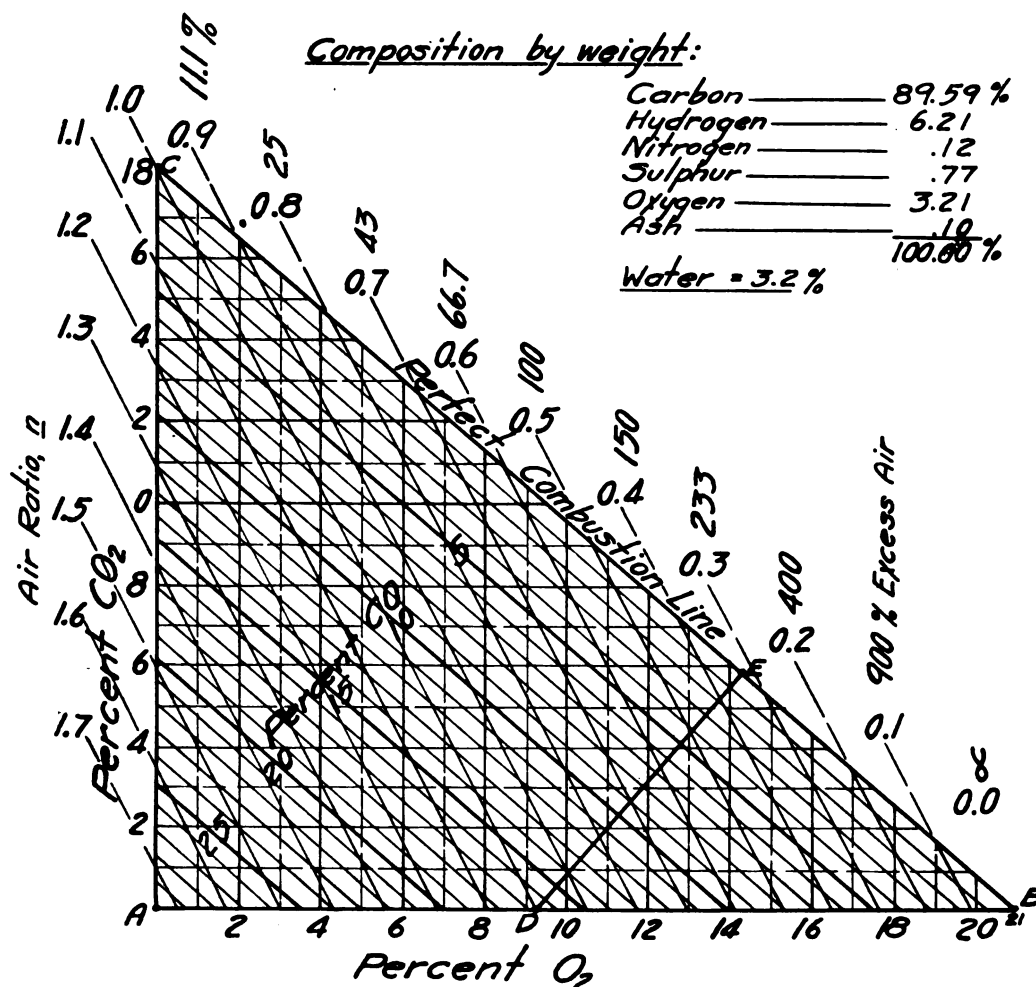


Fig. 2.

Chart for Stack Gas Analysis Calculated for Coke Oven Gas

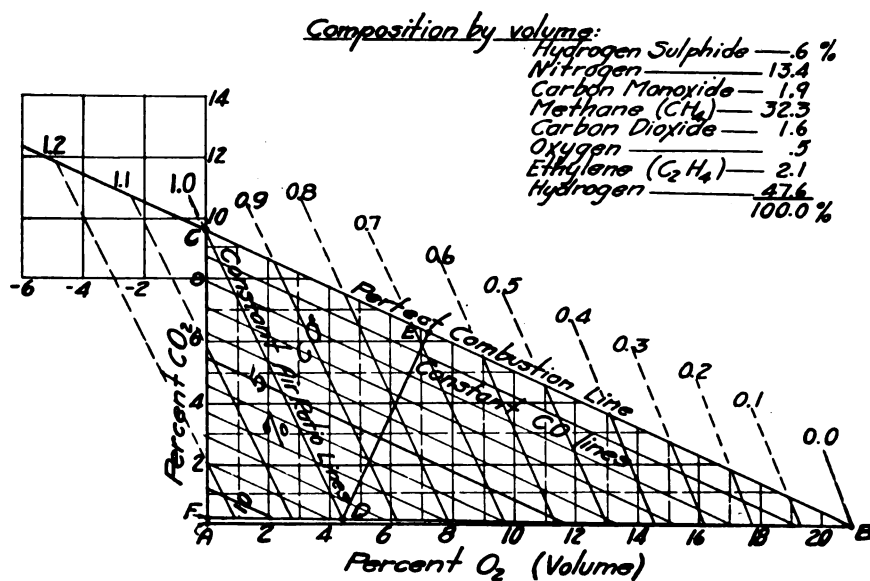


Fig. 3.

Chart for Stack Gas Analysis Calculated for Natural Gas

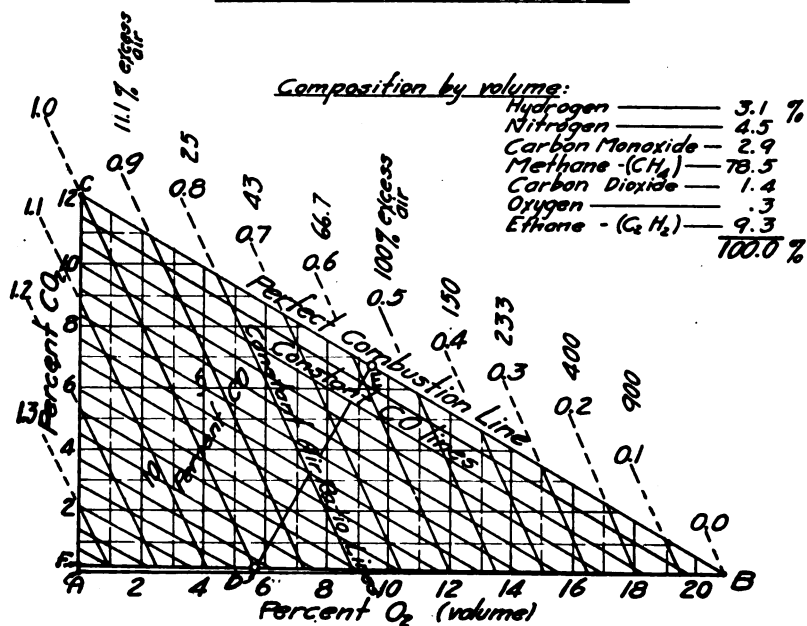


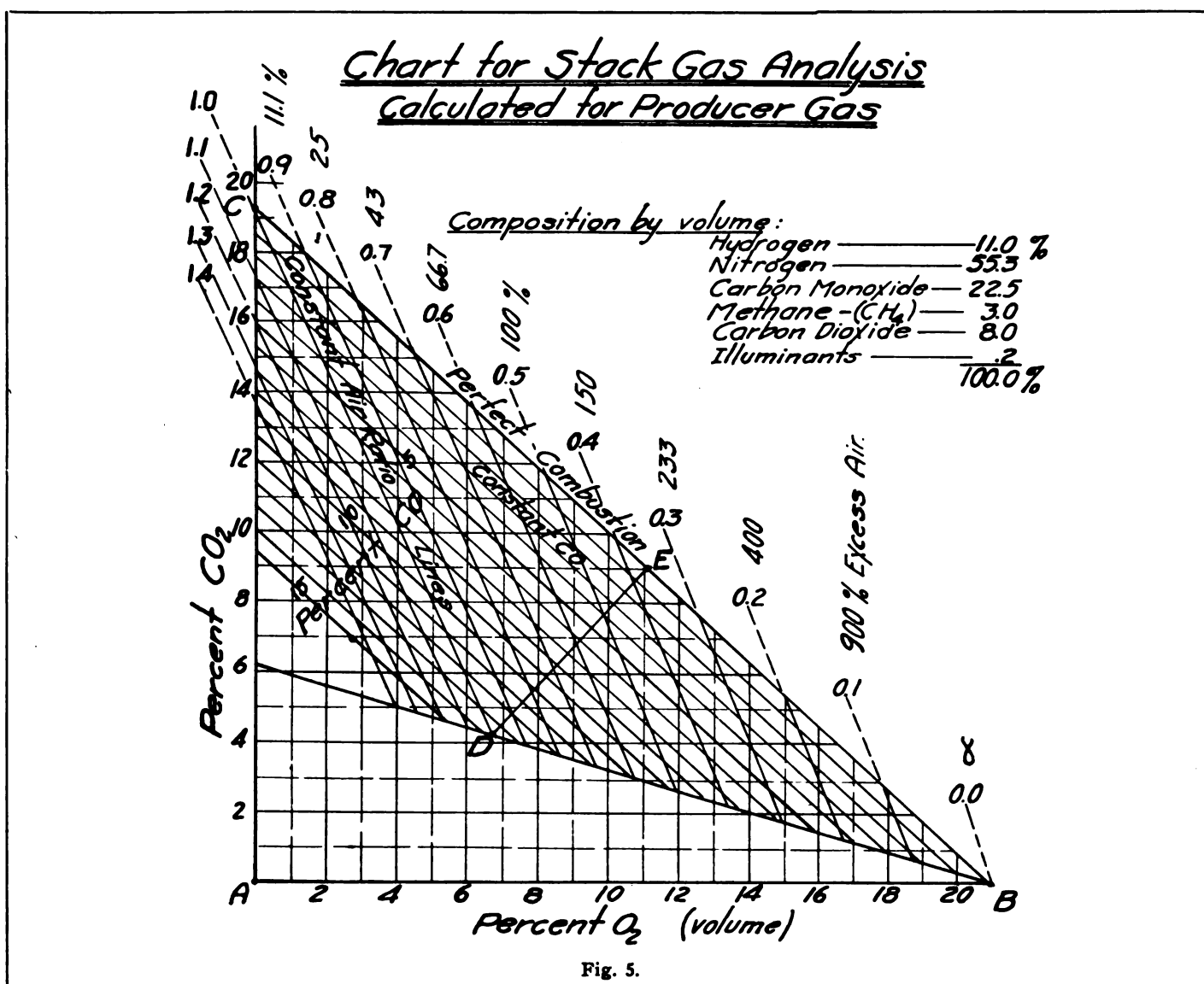
Fig. 4.

 $O_{\min} =$

$$30 \times .7625 + 89 \left(.0495 - \frac{.0653}{8} \right) = 26.55 \text{ cubic}$$

feet of O_2 per pound of coal.
 $k =$

$$\frac{3000 \times .7625}{30 \times .7625 + 26.55 \left(\frac{4.76}{n} - 1 \right)} = \frac{100 n}{n + 5.52 - 1.16 n}$$



$$O_2 \text{ content} = q = \frac{100 n}{5.52 - .16 n}$$

$$O_{min} \left(\frac{1}{n} - 1 \right) \times 100$$

$$= \frac{30 c_1 + O_{min} \left(\frac{4.76}{n} - 1 \right)}{100 n}$$

$$26.55 \left(\frac{1-n}{n} \right) \times 100$$

$$30 \times .7625 + 25.55 \left(\frac{4.76-n}{n} \right)$$

$$= \frac{100 (1-n)}{.861 n + (4.76-n)} = \frac{100 (1-n)}{4.76 - .139 n}$$

From these equations are calculated the CO₂ and oxygen content for various values of n , as shown in Table I.

TABLE I.

$n =$	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	0	1.1	1.2	1.3	1.4	1.5	1.6
$.160 n =$	.16	.144	.128	.112	.096	.080	.064	.048	.032	.016	0	.176	.192	.208	.224	.240	.256
$(5.52 - .160 n) =$	5.36	5.376	5.392	5.408	5.424	5.440	5.456	5.472	5.488	5.504	5.52	5.344	5.328	5.312	5.296	5.280	5.264
$CO_2 \text{ content} = k = \frac{100 n}{(5.52 - .160 n)} =$	18.66	16.77	14.87	12.93	11.07	9.20	7.34	5.48	3.64	1.81	0	20.60	22.53	24.45	26.45	28.40	30.40
$.139 n =$	.139	.1251	.1112	.0973	.0834	.0695	.0556	.0417	.0278	.0139	0	.153	.167	.181	.195	.208	.222
$(4.76 - .139 n) =$	4.621	4.635	4.649	4.663	4.677	4.691	4.704	4.718	4.732	4.746	4.760	4.607	4.593	4.579	4.565	4.552	4.538
$(1 - n) =$	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	-.1	-.2	-.3	-.4	-.5	-.6
$O_2 \text{ content} = q = \frac{100 (1-n)}{(4.76 - .139 n)} =$	0	2.16	4.30	6.47	8.55	10.68	12.76	14.83	16.91	18.99	21.00	-2.17	-4.35	-6.55	-8.75	-11.00	-13.23

Each point determined by the values of k and of q for a given value of n , must be on the straight line CB, which is drawn connecting the point $k_{\max} = 18.66$ with point $q_{\max} = 21.0$. This is a test of the correctness of the calculations. The line CB is extended to the left, and the points laid off on it for n greater than 1 are used for drawing the air factor lines for these values of n .

The part of the diagram to the left of line AC consists of construction lines only. The field enclosed in the triangle ACB includes all possible stack gas analyses, provided that all hydrogen has been burned to H_2O —which means most practical cases.

b) Incomplete combustion—points on axis of abscissas AB:

CO content = $p =$

$$30 c_1 + \frac{3000 c_1}{n} O_{\min} - O'_{\min}$$

$$O_{\min} = 26.55 \text{ as above. } O'_{\min} = 15 c_1 + 89 h_1 \\ = 15 \times .7625 + 89 (.0495 - \frac{.0653}{8}) \\ = 15.113 \text{ cu. ft. } O_2 \text{ per pound of coal.}$$

$$p = \frac{3000 \times .7625}{30 \times .7625 + \frac{4.76}{n} \times 26.55 - 15.113}$$

$$p = \frac{100 n}{5.52 + .339 n}$$

$$O_2 \text{ content} = q = \frac{(\frac{1}{n} O_{\min} - O'_{\min}) \times 100}{30 c_1 + \frac{4.76}{n} O_{\min} - O'_{\min}} \\ = \frac{(\frac{1}{n} \times 26.55 - 15.113) \times 100}{30 \times .7625 + \frac{4.76}{n} \times 26.55 - 15.113} \\ = \frac{(\frac{1}{n} - .570) \times 100}{\frac{4.76}{n} + .291}$$

$$q = \frac{100 (1.757 - n)}{8.36 + .511 n}$$

Points obtained from these equations are shown in Table II.

The points for O_2 content are located on the line AB. Through these and their corresponding points for the same air factor n on line CB (calculated in a), are drawn the straight lines representing constant air factors. Line CD, with $n = 1$, divides the field of excess air conditions (to the right of CD) from the field of air deficiency conditions (to the left of CD). Constant CO lines are parallel to CB and are equally spaced. Length DE represents 17.05 per cent CO, as shown in Table II for $n = 1$.

Examples following will show the method of using the chart:

Point I. Stack gas analysis showed $CO_2 = 13.0$ per cent, $O_2 = 6.3$ per cent.

From Fig. 1, $CO = 0$ (complete combustion), $n = .70$; $\frac{1}{n} = 1.43$, or 43 per cent excess air.

Point II. $CO_2 = 13.0$ per cent, $O_2 = 1.0$ per cent.

From Fig. 1, $CO = 7.2$ per cent; $n = 1.125$; $\frac{1}{n} = .89$, or 11 per cent deficiency of air.

Point III. $CO_2 = 13.0$ per cent, $O_2 = 5.0$ per cent.

From Fig. 1, $CO = 1.8$ per cent; $n = .80$; $\frac{1}{n} = 1.25$, or 25 per cent excess air.

In spite of this excess air, combustion is incomplete.

This may be caused by imperfect mixture of air with the gases rising from the coal, or by chilling of the gases.

A chart for coal tar, calculated in a similar manner, is shown in Fig. 2.

The only case in which the chart for coal, in Fig. 1, will not give correct results, is that in which there is deficiency of air and the temperature is not high enough to cause complete combustion of the hydrocarbons. For instance, in sheet heating furnaces using bituminous coal on the grate, where it is necessary to have in the furnace a flame containing hydrocarbons, the latter may break up, and produce soot (free carbon), or they may pass out unchanged. In either event, the

TABLE II.

$n =$	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	0	1.1	1.2	1.3	1.4	1.5	1.6
$\frac{5.52}{n}$	5.520	6.130	6.900	7.890	9.200	11.040	13.800	18.400	27.600	55.200		5.015	4.600	4.250	3.945	3.680	3.453
$(\frac{.339 + 5.52}{n})$	5.859	6.469	7.239	8.229	9.539	11.379	14.139	18.739	27.939	55.539		5.354	4.939	4.589	4.284	4.019	3.792
$CO_2 \text{ content} = p = \frac{100}{(.339 + 5.52/n)}$	17.05	15.47	13.82	12.16	10.49	8.79	7.07	5.33	3.58	1.80	0	18.70	20.27	21.82	23.35	24.87	26.40
$.511 n$	.511	.460	.409	.358	.307	.256	.205	.153	.102	.051	0	.562	.614	.665	.716	.766	.818
$(8.36 + .511 n)$	8.871	8.820	8.769	8.718	8.667	8.616	8.565	8.513	8.462	8.411	8.36	8.922	8.974	9.025	9.076	9.126	9.178
$(1.757 - n)$	.757	.857	.957	1.057	1.157	1.257	1.357	1.457	1.557	1.657	1.757	.657	.557	.457	.357	.257	.157
$O_2 \text{ content} = q = \frac{100 (1.757 - n)}{8.36 + .511 n}$	8.54	9.72	10.91	12.11	13.34	14.58	15.82	17.10	18.38	19.70	21.00	7.36	6.21	5.07	3.94	2.82	1.71

flue gas analysis would not check with the chart.

II. Method for Gaseous Fuels. (Fig. 3.)

Let one cubic foot of fuel gas contain h_1 cu. ft. of H_2 , p_1 cu. ft. of CO , N_1 cu. ft. of Nitrogen, v_1 cu. ft. of CH_4 , k_1 cu. ft. of CO_2 , q_1 cu. ft. of O_2 , r_1 cu. ft. of C_2H_4 , s_1 cu. ft. of C_2H_2 . Let one cu. ft. of dry flue gas contain k per cent CO_2 , p per cent CO , q per cent O_2 .

(a) Complete combustion, without formation of CO — line CB, Fig. 2.

- 1) $2 H_2 + O_2 = 2 H_2O$; 1 cu. ft. H_2 requires 0.5 cu. ft. O_2 . H_2O disappears.
- 2) $2 CO + O_2 = 2 CO_2$; 1 cu. ft. CO requires 0.5 cu. ft. O_2 and produces 1 cu. ft. CO_2 .
- 3) $CH_4 + 2 O_2 = CO_2 + 2 H_2O$; 1 cu. ft. CH_4 requires 2 cu. ft. O_2 and produces 1 cu. ft. CO_2 .
- 4) CO_2 passes into the flue gas without change. 1 cu. ft. CO_2 produces 1 cu. ft. CO_2 .
- 5) $C_2H_4 + 3 O_2 = 2 CO_2 + 2 H_2O$; 1 cu. ft. C_2H_4 requires 3 cu. ft. O_2 and produces 2 cu. ft. of CO_2 .
- 6) $2 C_2H_2 + 5 O_2 = 4 CO_2 + 2 H_2O$; 1 cu. ft. C_2H_2 requires $2\frac{1}{2}$ cu. ft. O_2 and produces 2 cu. ft. CO_2 .

Theoretical oxygen volume for 1 cu. ft. of fuel gas = $O_{min} = .5h_1 + .5p_1 + 2. v_1 + 3. r_1 + 2.5 s_1 - q_1$.

Actual oxygen volume for 1 cu. ft. of stack gas =

$$O_a = \frac{1}{n} O_{min}.$$

Dry stack gas volume from 1 cu. ft. of fuel gas = $[CO_2 = p_1 + v_1 + k_1 + 2 r_1 + 2 s_1 = A = k$ per cent of stack gas volume]

$$+ [N = N_1 + \frac{79}{21} \frac{1}{n} O_{min}] + [O_2 = \frac{1}{n} O_{min} - O_{min} = q \text{ per cent of stack gas volume.}]$$

Solving for CO_2 content = $k =$

$$\frac{100 A}{A + N_1 + \frac{79}{21} \frac{1}{n} O_{min} + \frac{1}{n} O_{min} - O_{min}} = \frac{100 A}{A + N_1 + (\frac{4.76}{n} - 1) O_{min}}$$

O_2 content = $q =$

$$\frac{100 O_{min} (\frac{1}{n} - 1)}{A + N_1 + O_{min} (\frac{4.76}{n} - 1)}$$

As before, different values of n furnish corresponding points on line CB (this time in Fig. 3).

(b) Incomplete combustion without formation of CO_2 , but with complete combustion of hydrogen, — points on the straight line BF. All carbon burned to CO .

- 1) $2 H_2 + O_2 = 2 H_2O$; 1 cu. ft. H_2 requires 0.5 cu. ft. O_2 ; water vapor disappears.
- 2) CO remains unchanged; 1 cu. ft. CO in fuel produces 1 cu. ft. of CO in the stack gas.

- 3) $2 CH_4 + 3 O_2 = 2 CO + 4 H_2O$; 1 cu. ft. CH_4 requires 1.5 cu. ft. O_2 and produces 1 cu. ft. CO .
- 4) CO_2 remains unchanged; 1 cu. ft. of CO_2 in fuel produces 1 cu. ft. CO_2 in stack gas.
- 5) $C_2H_4 + 2 O_2 = 2 CO + 2 H_2O$; 1 cu. ft. C_2H_4 requires 2 cu. ft. O_2 and produces 2 cu. ft. CO .
- 6) $2 C_2H_2 + 3 O_2 = 4 CO + 2 H_2O$; 1 cu. ft. C_2H_2 requires 1.5 cu. ft. O_2 and produces 1 cu. ft. CO .

From these equations follows the theoretical air volume for 1 cu. ft. of fuel:

$$O'_{min} = .5 h_1 + 1.5 v_1 + 2 r_1 + 1.5 s_1 - q_1.$$

Actual oxygen volume for 1 cu. ft. of fuel gas with the same air volume as under (a) = $O_a = \frac{1}{n} O_{min}$. Dry

stack gas volume resulting from 1 cu. ft. of fuel = $[CO_2 = k_1 = k$ per cent of stack gas volume] + $[CO = p_1 + v_1 + 2 r_1 + 2 s_1 = B = p$ per cent of stack gas volume] + $[N = N_1 + \frac{79}{21} \frac{1}{n} O_{min}] + [O_2 = \frac{1}{n} O_{min} - O'_{min} = q$ per cent of stack gas volume].

From this follows:

CO_2 content = $k =$

$$\frac{100 k_1}{k_1 + B + N_1 + \frac{79}{21} \frac{1}{n} O_{min} + \frac{1}{n} O_{min} - O'_{min}} = \frac{100 k_1}{k_1 + B + N_1 + \frac{4.76}{n} O_{min} - O'_{min}}$$

CO content = $p =$

$$\frac{100 B}{k_1 + B + N_1 + \frac{4.76}{n} O_{min} - O'_{min}}$$

O_2 content = $q =$

$$\frac{(\frac{1}{n} O_{min} - O'_{min}) \times 100}{k_1 + B + N_1 + \frac{4.76}{n} O_{min} - O'_{min}}$$

These equations give points on the straight line BF. The lines of constant air ratios are those joining points on CB with corresponding points on BF, calculated for the same value of n .

It is advisable to place the CO divisions on the line DE, which is drawn perpendicular to CB and passes through intersection D of line BF with the air ratio line for $n = 1$.

A numerical example will be given for coke oven gas, of the following composition (percentages by volume):

Hydrogen	H_2	47.6%	h_1
Carbon monoxide	CO	1.9%	p_1
Nitrogen	N	13.4%	N_1
Methane	CH_4	32.3%	v_1
Carbon dioxide	CO_2	1.6%	k_1
Oxygen	O_2	0.5%	q_1
Ethylene	C_2H_4	2.1%	r_1
Hydrogen sulphide	H_2S	0.6%	
		100.0%	

(a) Complete combustion,—calculation for points on line CB.

$$\text{CO}_2 \text{ content} = k =$$

$$\frac{100 A}{A + N_1 + \left(\frac{4.76}{n} - 1\right) O_{\min}}$$

$$A = p_1 + v_1 + k_1 + 2 r_1 + 2 s_1 = .019 + .323 + .016 + .042 + 0 = .400$$

$$O_{\min} = .5 h_1 + .5 p_1 + 2 v_1 + 3 r_1 + 2.5 s_1 - q_1 = .5 \times .476 + .5 \times .019 + 2 \times .323 + 3 \times .021 + 2.5 \times 0 - .005$$

$$= .951 \text{ cu. ft. oxygen per cu. ft. of fuel. } N_1 = .134$$

$$k = \frac{100 \times .400}{.400 + .134 + \left(\frac{4.76}{n} - 1\right) \times .951}$$

$$= \frac{100}{1 + .335 + \left(\frac{4.76}{n} - 1\right) \times 2.375}$$

$$k = \frac{100}{1.335 + \frac{11.305}{n} - 2.375} = \frac{100 n}{11.305 - 1.04 n}$$

$$\text{Oxygen content} = q =$$

$$\frac{100 O_{\min} \left(\frac{1}{n} - 1\right)}{A + N_1 \times O_{\min} \left(\frac{4.76}{n} - 1\right)}$$

$$= \frac{100 \times .951 \left(\frac{n - 1}{n}\right)}{.400 + .134 + .951 \left(\frac{4.76 - n}{n}\right)}$$

$$= \frac{100 \left(\frac{n - 1}{n}\right)}{.562 \frac{n}{n} + \left(\frac{4.76 - n}{n}\right)} = \frac{100 (n - 1)}{4.76 - .438 n}$$

From these equations are calculated the CO_2 and oxygen content for various values of n , as shown in table III.

TABLE III.

$n =$	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	0	1.1	1.2	1.3	1.4	1.5	1.6
$1.04 n =$	1.040	.936	.832	.728	.624	.520	.416	.312	.208	.104	0	1.144	1.248	1.352	1.456	1.560	1.662
$(11.305 - 1.04 n) =$	10.265	10.369	10.467	10.577	10.681	10.785	10.889	10.993	11.097	11.201	11.305	10.161	10.057	9.953	9.849	9.745	9.643
$\text{CO}_2 \text{ content} = k = \frac{100 n}{(11.305 - 1.04 n)} =$	9.74	8.69	7.65	6.61	5.62	4.64	3.67	2.75	1.80	.89	0	10.83	11.91	13.09	14.20	15.40	16.60
$.438 n =$	.438	.394	.350	.306	.263	.219	.175	.131	.088	.044	0	.482	.526	.570	.614	.657	.701
$(4.76 - .438 n) =$	4.322	4.366	4.410	4.454	4.497	4.541	4.585	4.629	4.672	4.716	4.760	4.278	4.234	4.190	4.146	4.103	4.059
$(n - 1) =$	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	-.1	-.2	-.3	-.4	-.5	-.6
$\text{O}_2 \text{ content} = q = \frac{100 (n - 1)}{(4.76 - .438 n)} =$	0	2.29	4.53	6.73	8.90	11.02	13.10	15.12	17.13	19.10	21.0	2.34	4.72	7.16	9.65	12.19	14.77

As before, each point determined by the values of k and q corresponding to a given value of n , must lie on the straight line CB, in Fig. 3, drawn connecting the point $k_{\max} = 9.74$ with point $q_{\max} = 21.0$. This is a test of the correctness of the calculations. As

before, the line CB is extended to the left of C, to furnish air ratio lines for n greater than 1. All possible stack gas analyses for this fuel are represented by the field enclosed in the triangle BCF, provided no hydrogen remains unburned.

(b) Incomplete combustion,—Points on line BF.

$$\text{CO content} = p =$$

$$\frac{100 B}{k_1 + B + N_1 + \frac{4.76}{n} O_{\min} - O'_{\min}}$$

$$B = p_1 + v_1 + 2 r_1 + 2 s_1 = .019 + .323 + 2 \times .021 + 2 \times 0 = .384$$

$$k_1 = .016 \quad N_1 = .134 \quad O_{\min} = .951 \text{ (same as "a")}$$

$$O'_{\min} = .5 h_1 + 1.5 v_1 + 2 r_1 - 1.5 s_1 - q_1 = .5 \times .476 + 1.5 \times .323 + 2 \times .021 - 1.5 \times 0 - .005 = .759 \text{ cu. ft. O}_2 \text{ per cu. ft. fuel gas.}$$

$$\text{CO content} = p =$$

$$\frac{100 \times .384}{.016 + .384 + .134 + \frac{4.76}{n} \times .951 - .759}$$

$$= \frac{100 \times .384}{4.76 \times .951 - .225}$$

$$= \frac{100 n}{11.80 - .585 n}$$

$$\text{O}_2 \text{ content} = q =$$

$$\frac{\left(\frac{1}{n} O_{\min} - O'_{\min}\right) \times 100}{k_1 + B + N_1 + \frac{4.76}{n} O_{\min} - O'_{\min}}$$

$$= \frac{\left(\frac{.951 - .759 n}{n}\right) \times 100}{\frac{4.76 \times .951}{n} - .225}$$

$$= \frac{100 (1 - .798 n)}{(4.76 - .237 n)}$$

$$\text{CO}_2 \text{ content} = k =$$

$$\frac{100 k_1}{k_1 + B + N_1 + \frac{4.76}{n} O_{\min} - O'_{\min}}$$

$$= \frac{100 \times .016}{4.76 \times .951} - .255$$

$$= \frac{100 n}{282.5 - 14.06 n}$$

and their corresponding points on CB for equal values of n , are drawn the straight lines representing constant air ratios. The CO divisions are marked off on line DE, drawn perpendicular to CB, and passing through that O_2 point of line BF for which $n = 1$. Length DE then represents 8.90 per cent CO, as shown in Table IV for the value $n = 1$.

TABLE IV.

$n =$	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	0	1.1	1.2	1.3	1.4	1.5	1.6
.585 $n =$	.585	.526	.468	.410	.351	.293	.234	.176	.117	.059	0	.644	.702	.760	.819	.878	.936
(11.80 — .585 $n =$	11.215	11.274	11.332	11.390	11.449	11.507	11.566	11.624	11.683	11.741	11.800	11.856	11.908	11.960	10.981	10.922	10.864
CO content = $p = \frac{100 n}{11.80 - .585 n} =$	8.90	7.99	7.06	6.15	5.24	4.34	3.46	2.58	1.71	.85	0	9.85	10.82	11.77	12.76	13.73	14.72
14.06 $n =$	14.06	12.65	11.25	9.83	8.43	7.02	5.62	4.22	2.81	1.41	0	15.47	16.88	18.28	19.69	21.08	22.48
(282.5 — 14.06 $n =$	268.44	269.85	271.25	272.67	274.07	275.48	276.88	278.28	279.69	281.09	282.50	267.03	265.62	264.22	262.81	261.42	260.02
CO_2 content = $k = \frac{100 n}{282.5 - 14.06 n} =$	.37	.33	.30	.26	.22	.18	.15	.11	.07	.03	0	.41	.45	.49	.53	.58	.62
.237 $n =$	.237	.213	.190	.166	.142	.118	.095	.071	.047	.024	0	.261	.284	.308	.332	.356	.380
(4.76 — .237 $n =$	4.523	4.547	4.570	4.594	4.618	4.642	4.665	4.689	4.713	4.736	4.760	4.499	4.476	4.452	4.428	4.404	4.380
.798 $n =$	.798	.718	.639	.559	.479	.399	.319	.240	.160	.080	0	.878	.957	1.039	1.119	1.198	1.278
(1 — .798 $n =$	.202	.282	.361	.441	.521	.601	.681	.760	.840	.920	1.000	.122	.043	-.039	-.119	-.198	-.278
O_2 content = $q = \frac{100 (1 - .798 n)}{4.76 - .237 n} =$	4.46	6.20	7.90	9.60	11.28	12.97	14.61	16.22	17.82	19.47	21.0	2.71	.96	-.89	-2.69	-4.50	-6.35

From these equations are calculated the CO, oxygen, and CO_2 content for various values of n , as shown in Table IV.

The points on the straight line BF, Fig. 3, are located by means of the O_2 and CO_2 contents shown in Table IV, for given values of n . Through these points

The lines of constant CO are drawn parallel to CB and are evenly spaced. Lines of constant air ratio, though straight, are not parallel to each other, nor are their intersection points on CB evenly spaced.

Charts for other gaseous fuels have been calculated in a similar manner, and are shown in Figures 4 and 5.

Superpower Plan Would Over-come Large Waste

Recent investigations by the United States Geological Survey, Department of the Interior, in what is known as the superpower zone—the dense industrial region between Washington and Boston—show a waste of coal used in the production of power by the industrial establishments in this zone in the year 1919 to the amount of 13,502,100 tons. In other words, the energy developed by these establishments by the burning of 19,125,900 tons of coal could have been developed in large central power plants by the burning of 5,623,800 tons. This was a waste through inefficient independent power production of 71 per cent in coal consumption.

The industry using the largest amount of coal in the region is anthracite mining, and in this industry a coal saving of more than 75 per cent could be made if the mines were supplied from an efficient central electric power system. Many industries, it is stated,

could save coal by the use of waste-heat boilers. Probably the greatest saving by this means could be made in the cement industry. It is estimated that if waste-heat boilers had been in use in 1919 in all the cement plants in the superpower zone, 540,000 tons of coal would have been saved in that single industry.

There are many blast furnaces in the superpower zone which are isolated from any steel plants or rolling mills, and approximately half their gases are wasted. These wasted gases would produce sufficient heat for boilers to generate 500,000,000 kilowatt-hours a year.

In certain plants the low-pressure steam requirements greatly exceed the power requirements, and there is no reason why such plants should not generate by-product power and sell it to the electrical distributing companies.

Men Who Helped to Make the Steel Industry



JOSEPH GREEN BUTLER, JR.

Sketch of Career of Joseph G. Butler, Jr.

JOSEPH GREEN BUTLER, JR., was born at Temperance Furnace, Mercer County, Pa., on December 21, 1840. His father was Joseph Green Butler, and his mother, Temperance Orwig Butler, the former having been an ironmaster and the latter descended from one of the oldest families in Berks County, Pa., although born at Salem, Ohio, whither her parents had removed with the earliest settlers of that state.

The lineage of the Butler family is worthy of being recorded here, not only because it can be traced back for almost a thousand years, but because of the extremely prominent part members of the family played in the American Revolution and their activity in the earlier years of the Republic. The family became noted in Ireland under the reign of Henry II, ruling the Palatinate of Ormond, now County of Tipperary. It had a large part in the political and religious history of the country until the early part of the Eighteenth Century, when political troubles led to the immigration to America of Thomas and William Butler. These two brothers, together with five of their sons, held commissions in the American Army during the Revolution, acquitting themselves in such a way as to lead General Washington, at a banquet held after the surrender of Lord Cornwallis at Yorktown, to offer a toast to their loyalty and courage, using the following words: "To the Butlers and their five sons." This toast was responded to by General Lafayette with the observation that, when he wanted anything well done, he had a Butler do it. During the troublesome times following the close of the War for Independence, these Butlers served the country faithfully in the Indian wars of the period, as well as other capacities. Gen. Richard Butler, son of Thomas and Ann Dalrymple Butler, was killed at the battle of the Miamis, in Ohio, and his cousin, Col. Edward Butler, son of William Butler, was wounded in the same struggle with the savages.

The personal acquaintance between General Washington and Col. Thomas Butler, original ancestor in America of the subject of this sketch, doubtless led to Col. Butler becoming interested in the manufacture of iron, as General Washington and his brother had erected a small blast furnace in Virginia shortly after the close of the Revolution. He was later engaged as a charcoal contractor, furnishing fuel for a number of blast furnaces in Pennsylvania, being connected in this way with such famous pioneer iron firms as Spang, Lyon & Shorb, the Shoenbergers, and others. He followed this occupation to the end of his life, and his six sons were also engaged in it. Col. Thomas Butler died at the home of his son, David, near Roaring Springs, Pa., in 1832, at the age of 92 years.

Of the six sons above referred to, the last was Joseph, born January 7, 1779, at Milesburg, Center County, Pa., where his father was connected with the first blast furnace built in Central Pennsylvania. This stack was erected by Col. Samuel Miles and Col. Patton, both officers in the Revolutionary Army. Joseph Butler married Esther Green, whose mother was a sister of Col. Samuel Miles. The Miles family was

of Welsh descent, having come to America with, or shortly after William Penn, and having been prominent in the affairs of Philadelphia, Col. Samuel Miles being Mayor of the City at one time. To this union were born two sons and three daughters, of whom Joseph Green Butler, father of Joseph Green Butler, Jr. was the youngest. After the death of Esther Green Butler, Joseph Butler married again, his second wife being Rachel Gould Parker, by whom he had a number of children. The children of the first marriage were reared by the mother's family, the two groups being thus separated and, scattering to different parts of the country, were unknown to one another for many years. Joseph Butler was an ironmaster of considerable note. With his father and his brother, James, he conducted a forge at Bellefonte, producing blooms of such excellence that the name under which they were sold, "Juniata Blooms" was preserved and used long after the original forge and its owners had passed away. He served in the War of 1812, and was prominent in the affairs of his community, having been selected to keep the "inn or house of public entertainment" at Bellefonte in 1816. He was also elected sheriff of Center County in 1821.

Joseph Green Butler, son of Joseph Butler and Esther Green, was, like his father before him and his son, Joseph Green Butler, Jr., an ironmaster of reputation. For some years he followed the iron business in Central Pennsylvania. As the ore and fuel supplies in that Section became exhausted, he came westward and was soon recognized as an expert in Western Pennsylvania and Eastern Ohio, then beginning to be known as iron producing territory. After spending some time as manager for different furnace companies, he became associated with some eastern people in the operation of a blast furnace at New Wilmington, Pa., succeeding in the management of this enterprise William McKinley, father of President William McKinley. About 1838 he erected near Hadley, Mercer County, Pa., a small blast furnace, which he named "Temperance Furnace," after his wife, Temperance Orwig Butler. It was within a few feet of this stack that the subject of this sketch was born. Later Joseph Green Butler was Manager of furnaces for the famous old firm of James Ward & Company, which built the first bar mill in Ohio, at Niles. Still later he was in charge of the mercantile department of that firm. He was married to Temperance Orwig, and they had seven sons and three daughters. He died at Cleveland in 1895, and his wife survived him four years. Joseph Green Butler was a man of unusual attainments and character, enjoying the respect and esteem of a wide circle of friends.

Joseph Green Butler, Jr., subject of this sketch, was the third son of Joseph Green Butler and Temperance Orwig Butler. He was about one year old when his father removed from Temperance Furnace to Niles, Ohio, in order to take charge of the mercantile department of James Ward & Company. At Niles, therefore, he spent his entire boyhood, with the exception of one year, 1853, during which his father managed a

blast furnace at New Wilmington. At Niles, he attended the village school, in company with William McKinley, afterward President of the United States, as well as of others who later became widely known. During his school years he seems to have been an apt pupil, but he was at the same time one of the most vigorous and resourceful of the group above referred to, and, in spite of the meager opportunities, acquired the foundation of a thorough education. He inherited from a long line of ancestors the courage, energy and ability which have enabled him to become one of the most widely known iron and steel manufacturers in the United States, and it is probable that his remarkable accomplishments in the field of industry, finance, art and letters may be credited to an indomitable spirit of achievement, derived from the mixture of Irish, Scotch and Welsh blood in his veins. Whatever may have been the source of this spirit, he has established a record of public and private achievement not often equalled, and his life and work form a source of inspiration for all who seek in the larger sense to make the world better for having lived in it.

Mr. Butler was about fifteen years of age, when, in 1855, he entered the store conducted by his father for James Ward & Company in the capacity of a clerk. In this position he made himself particularly useful by acquiring the Welsh language from the miners who patronized the establishment as well as helping to keep the accounts. One day Mr. Ward came into the store and announced that he wanted some one to fill the position of shipping clerk in the iron works, which was temporarily vacant. He selected Mr. Butler for the task, and this was so well performed that the young man was given the position permanently, and rapidly advanced until he became active in the management of the works. In 1858, his father was elected Sheriff of Trumbull County, removing, with the remainder of the family to Warren, the county seat. Mr. Butler, however, chose to remain with Ward & Company, and was taken into the Ward family, in which he made his home during the time he was with the firm, being later made Financial Manager of the Company.

In 1863, he became District Representative of Hale & Ayer, a Chicago firm, with whom he remained until 1866, resigning to become Manager of the Girard Iron Company, in which enterprise he was associated with David Tod, the famous "War Governor of Ohio," William Ward and William Richards. They built the first blast furnace in the Mahoning Valley, equipped with a closed top, and conducted the business under the name of the Girard Iron Company for twelve years, when he sold his interests to become Manager of the Brier Hill Iron Company. This was one of the most widely known iron-making establishments of its time, operating blast furnaces and later mining coal on a large scale. It continued successful operations for many years, being finally re-organized in 1912 under the name of the Brier Hill Steel Company, of which Mr. Butler, its original Manager is now Vice-President.

In the long interval between 1868 and 1912, Mr. Butler was connected with many other enterprises, and since that time his activities have been even still further extended. He was one of the organizers of the Ohio Steel Company, the first concern to make steel in the Mahoning Valley, being Vice President of the Company for a number of years. At this time he is a Director of The American Iron & Steel Institute, President of the Portage Silica Company, Vice-President of The Brier Hill Steel Company, Chairman of the Board

of Directors of The Bessemer Limestone & Cement Company, Director of The Youngstown Sheet & Tube Company, The Pennsylvania & Lake Erie Dock Company, The Cleveland & Mahoning Valley Railway Company, Pittsburgh, Youngstown & Ashtabula Railroad Company, New York, Pennsylvania & Ohio Light & Power Company, Youngstown & Suburban Railway, The Youngstown Municipal Railway Company, The Commercial National Bank, and numerous other less important enterprises. His business interests include almost every successful industrial enterprise in the Mahoning Valley, and he is interested in many similar undertakings elsewhere. His activities in the iron and steel business are especially notable, and his acquaintance among the leaders in this industry in all parts of the world is probably not exceeded by that of any living man, extending backward more than a generation and including all of those who had a large part in the modern development of steel manufacture in this country and abroad.

In spite of these multiplied interests, Mr. Butler has devoted a great deal of time to humanitarian work, as well as art and literature. Nor has he neglected politics, although he has never been a candidate for political office except when it offered no rewards except honors and an opportunity to serve his country. He has been a delegate to three Republican National Conventions, the last being that at which Warren G. Harding was nominated for President, Mr. Butler having been among the leaders of the long contest necessary to bring about that result. He has appeared before the Committee of Ways and Means and the Senate Finance Committee during the framing of almost every tariff bill since 1870, and has numbered among his personal friends, every Republican President since and including Grant. He took part in every Presidential election since and including that of Abraham Lincoln, and has been a consistent Republican during the whole period.

For many years Mr. Butler has been interested in art, and his collection of pictures is among the most notable in the United States, outside of New York. In 1918-19 Mr. Butler erected in the City of Youngstown one of the handsomest art galleries in the country, presenting it to the city, with an endowment fund to provide for its maintenance perpetually. This beautiful structure is devoted to the encouragement of American artists and now contains a large collection of choice paintings by American artists, all of which were donated by the builder. Connected with it is a free school of art instruction under able management.

Mr. Butler has gathered one of the finest private libraries in America. In addition he has written a number of widely known works, among these being "Life of McKinley," "First Trip Across the Continent," "First Trip Abroad," "Presidents I have Seen and Known," "A Journey Through France in War Time," "Fifty Years of Iron and Steel," and "History of Youngstown and the Mahoning Valley." Of these, the last named is in four volumes, "Fifty Years of Iron and Steel" is now in its Fifth Edition. All of these works were published privately.

Mr. Butler was, as has been noted, a boyhood friend and schoolmate of President William McKinley, and their close friendship endured through the whole of the martyred President's life. Many years ago he conceived the idea of erecting a memorial to mark the place of McKinley's birth, and, after years of labor, brought this idea to fruition in what is perhaps the

most beautiful and elaborate structure of this kind on the American continent. It is located at Niles, and is daily visited by people from all parts of the country and even many persons from abroad. This splendid memorial is of Georgia marble, with a heroic statue of McKinley as its crowning feature. It was designed by McKim, Mead & White and planned as an educational institution, containing art and memorabilia calculated to inspire study of history and love of country. Among these are a library, auditorium, museum of historical relics and many busts of the most famous men in the history of American politics, statesmanship and industry. Its cost, about half a million dollars, was defrayed largely by contributions from people in all walks of life, but the credit for its erection belongs entirely to Mr. Butler, who is President of the Organization erecting it, The National McKinley Birthplace Memorial Association.

In addition to the accomplishments here merely outlined along the line of industry, politics, art and literature, Mr. Butler has always been intensely interested in humanitarian work and has been connected with every movement of this kind in the Mahoning Valley for many years. Anything that offered an opportunity to inspire patriotism, instill pride in and affection for country and community, was eagerly embraced by him and given energetic and effective support. He was originator and one of the incorporators and is now a member of the Board of Governors of Sulgrave Institution, Sulgrave, England, through which the original home of the Washingtons has been preserved. He served as a member of the American Commission which visited France during the World War as guests of the French Government, and he has been at the head of community efforts, such as Red Cross, Council of National Defense, and all others designed to weld together patriotic and humanitarian sentiment. For seven years Mr. Butler served as President of the Youngstown Chamber of Commerce. He was at the same time President of the Youngstown Humane Society for five years. He has been Vice President General of the Sons of the American Revolution and President of The Mahoning Valley Historical Society and the Mahoning Institute of Art for many years. He is President of the American Pig Iron Association, and was President of the Organization which preceded it in the preparation of statistics concerning this great industry in America, the Bessemer Pig Iron Association.

Mr. Butler is a member of the following Clubs: Duquesne, Pittsburgh; Union, Cleveland; National Arts, Salmagundi, Republican, Grolier, India House and Friars, and the Ohio Society of New York.

He was married on January 10, 1866, to Harriet Voorhess Ingersoll, of an old and well known New Haven, Conn., family, whose death took place on April 27, 1921. Their children included, Blanche, wife of Edward L. Ford, of Youngstown (now deceased); Henry A., a well known business man of Youngstown, and Grace, wife of Arthur McGraw, of Detroit.

From the facts disclosed by the above simple sketch of his activities it is natural that Joseph Green Butler, Jr., should be the most widely known and most beloved citizen of the Mahoning Valley. The esteem and affection in which he is held have been repeatedly expressed publicly by his fellow citizens in the form of days specially set aside in his honor, as well as busts which have been unveiled—one at The Butler Art In-

stitute in Youngstown and another at the McKinley Memorial, in Niles, honors never bestowed on any other citizen of this locality. No other man has rendered such energetic and unselfish service to his country and his community, and he stands out among the historic figures of which northeastern Ohio has produced so large a number.

STEVENS INSTITUTE CELEBRATES ITS 50TH ANNIVERSARY.

Stevens Institute alumni and their friends joined in a 50th anniversary celebration at a notable dinner at Hotel Astor, New York, Thursday evening, Dec. 15. Among the 400 in attendance were a number of engineers who have won national distinction. At each guest's place was a brochure, well illustrated, recounting the 50 years of progress and service in the life of the Hoboken institution founded by Edwin A. Stevens and fostered by the members of his family. Stevens has had but two presidents, Henry Morton serving until 1902 and Alexander C. Humphreys immediately following him. The story of 50 years tells of the gifts made to Stevens in more recent years, including \$125,000 from Andrew Carnegie and alumni subscriptions of \$507,000.

A noteworthy feature of the dinner was the presence of the entire class of 1877. The 10 men who graduated in that year were applauded roundly as they answered to the call of the roll. They are named below:

- A. G. Brinckerhoff, secretary Nash Engineering Co., South Norwalk, Conn.
- M. I. Coster, vice-president Westinghouse Electric International Co., New York.
- W. E. Geyer, Boonton, N. J.
- F. E. Idell, mechanical engineer, 50 Church Street, New York.
- L. H. Nash, president Nash Engineering Co., South Norwalk, Conn.
- J. B. Pierce, Mercer County, Pa.
- J. Rapelje, Hopewell Junction, N. Y.
- E. P. Roberts, special consultant and manager Engineering Society of Akron, Akron, Ohio.
- E. A. Uehling, president Uehling Instrument Co., Passaic, N. J.
- F. VanWinkle, consulting engineer and associate editor "Power," New York.

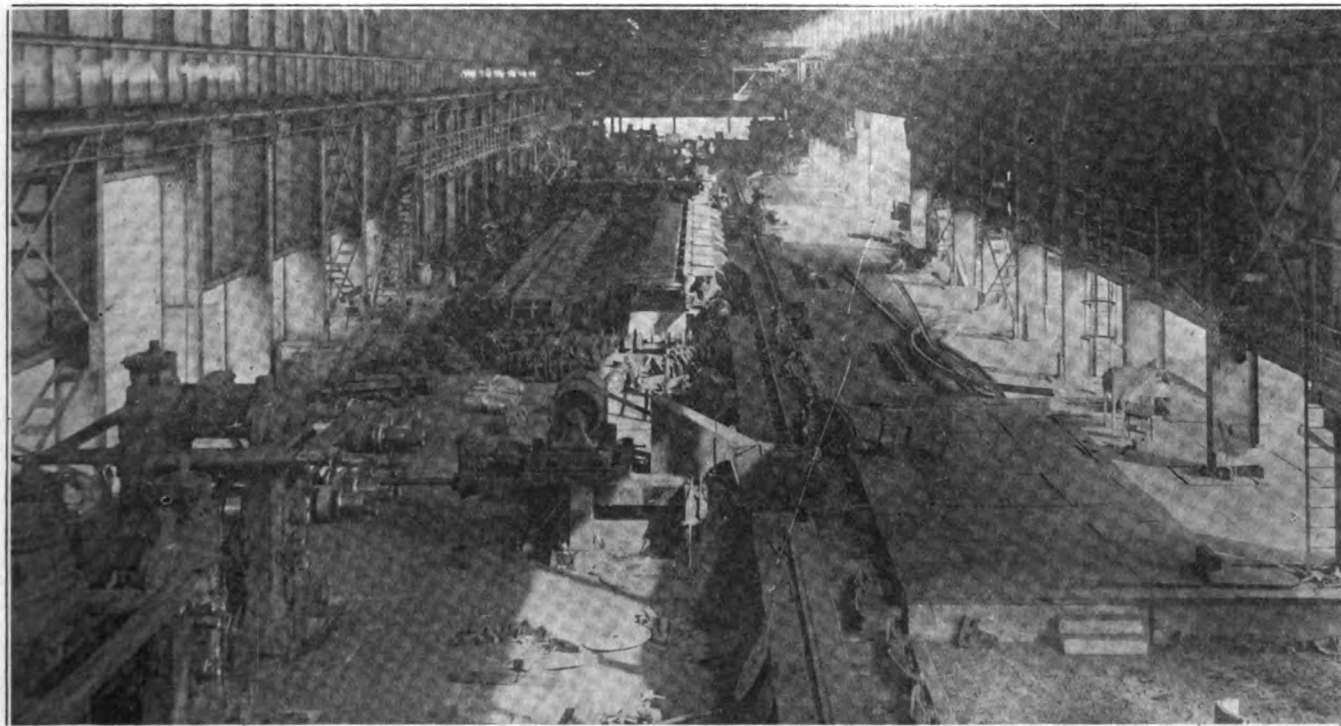
President Humphreys, in an address emphasizing some of the things for which Stevens Institute stands, challenged a statement made at a recent joint conference of the American Society of Mechanical Engineers and the American Society for the Promotion of Engineering Education. One of the speakers at that conference, a university professor, stated that colleges today are aiming at "quantity production" rather than quality of product. This speaker quoted the secretary of the second named society, who is dean of the engineering school of a university, to the effect that "there is no first-class engineering school in America." President Humphreys suggested that the pessimistic opinions of these professors may be attributable in part to the observed results of faulty teaching. To the charge of quantity production the speaker held that Stevens Institute is well justified in pleading not guilty. While there are no perfect institutions, "when we speak of 'first class,' that is relative, and so speaking I disagree with these men and claim there are a number of first class engineering schools in America, of which Stevens is one.

Rolling Mill Department

Electric Drives For Wire Mills

American Rolling Mills for France.

The Mansfield Sheet and Tin Plate Company's
New Steel Unit
By CARL W. PIERCE



Electric Drives For Wire Mills

A General Description of the Modern Electric Drives Recently
Installed in the Alabama City Works of the Gulf States Steel Co.

THE steel frame building which houses the wire-drawing benches is 240 feet wide, consisting of four 60-foot bays, and in length that portion devoted to wire-drawing is 340 feet, or 17 20-foot bays. Thus the floor area in this department is 81,600 square feet, all of which is laid with wood blocks. The roof is divided into alternately high and low sections, nearly flat, each 20 feet wide, extending across the full width of the building, 240 feet. The vertical space of 10 to 15 feet between the high and low sections of roof is walled en-

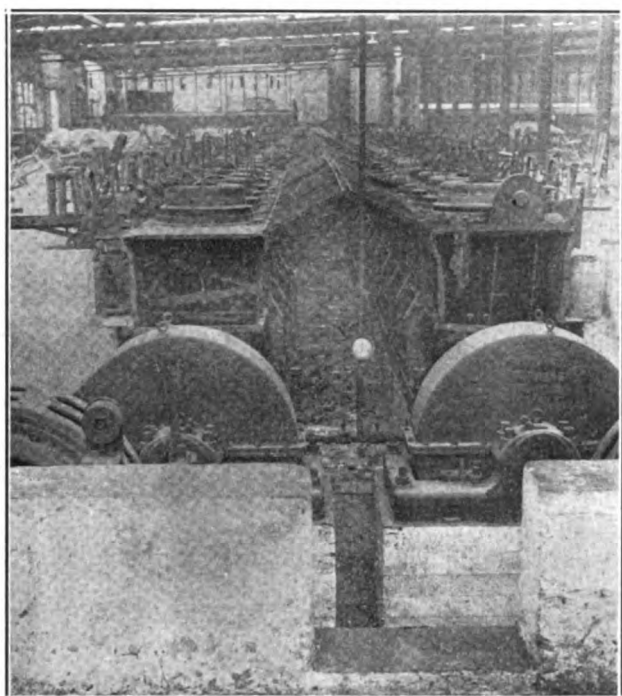


Fig. 1.

tirely with glass, thus giving very good natural lighting over the entire floor space.

Wire Drawing Frames.

There are six wire-drawing frames or benches, each about 175 feet long, running parallel with each other and in the direction of the length of the building; these, together with their drives, extend over about 10 20-foot bays, or 200 feet in the length of the building. As measured across the width of the building, the benches are separated by a distance of from 42 to 44 feet from center to center. The drawing benches were furnished by Humphrey & Sons, Joliet, Ill. Four of these (known as 1, 2, 3 and 4), each driven by a 230-volt d.c. motor, have been in service since the year 1910; the other two (Nos. 5 and 6), each of which is driven by 2,200-volt, 3-phase induction motor, were installed new and started up in August, 1920. Each one of the six benches carries 40 vertical wire-drawing drums or "blocks," and, at

intervals, called "pointers," used for tapering the end of the wire to a point so that it may be inserted by hand in the die hole. The old benches (1, 2, 3 and 4) are each provided with seven pointers, and the new benches (Nos. 5 and 6), each have 13 pointers. On the right in Fig. 1 is shown the chain drive to one of the pointers; this is on the end of bench No. 5.

As this picture shows, these two benches (Nos. 4 and 5) are installed close together, back to back, so that the work done on a given bench is all from one side. On the other hand, benches 1, 2, 3 and 4, which have a floor space between them of about 40 feet for location of the reels and for trucking, are built so that about half of the blocks draw from the right and the other half from the left side of the bench.

Old Bench Blocks.

The first block at the motor end of each of these benches is known as the "bull" block and runs at a speed of about 36 rpm., drawing the wire at a speed of about 250 feet per minute; this block is used to draw the heavy rolled rod as it comes from the rod mill after having been annealed and otherwise treated. There are located at intervals throughout the length of each of these benches 13 "ripping" blocks, which run at a speed of about 48 rpm., drawing the wire at a speed of about 330 feet per minute; these blocks are located next to the pointers.

The remaining 26 blocks on each of these benches are "finishing" blocks and run at about 72 rpm., drawing the wire at a speed of about 500 feet per minute.

Bevel Gearing.

A 53-tooth bevel, or miter, gear at lower end of vertical bull block shaft engages a 26-tooth split bevel gear on the line shaft; this latter gear is split in halves to facilitate the work of installing a new gear in event this should become necessary. This gives about a 2 to 1 gear reduction from line shaft to block. A 45-tooth bevel gear on the line shaft, giving a speed reduction of $1\frac{1}{2}$ to 1 from line shaft to block.

A 40-tooth bevel gear on the vertical finishing block shaft engages a 40-tooth split gear on the line shaft; thus the finishing block runs at line shaft speed, 72 rpm.

New Bench Blocks.

Benches Nos. 5 and 6 each have 13 ripping blocks which run at 48 rpm.; these are each located next to a pointer. The remaining 27 finishing blocks on each of these two benches run at a speed of 72 rpm. The speeds at which the wire is drawn on these benches is the same as those on the four old benches, viz., 330 ft. per minute for the ripping blocks and 500 ft. per minute for the finishing blocks.

Gearing.

The bevel gear on the ripping block shaft has 45 teeth and the one with which it engages on the line shaft has 30-teeth, or a reduction in speed of $1\frac{1}{2}$ to 1 from line shaft to block.

The bevel gear on the finishing block shaft and that with which it meshes, on the line shaft, each have 40 teeth; thus the finishing block runs at line shaft speed.

The 40 vertical shafts on each bench revolve at all times when the line shaft is running; and in each case the vertical shaft drives the block through a friction clutch which permits the block to be stopped or started instantly.

To the block there is attached a chain, on the end of which is fastened a pair of grip jaws which are adjusted

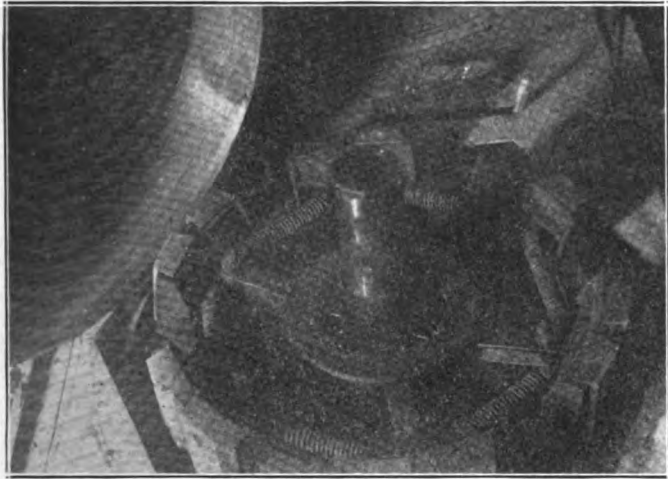


Fig. 2.

to take hold of the end of the wire after it has been threaded through the die hole. The clutch is then let in gradually by lifting the foot, after the manner of the left pedal of an automobile; this causes the block to revolve at the same speed as the vertical shaft which carries it.

Friction Clutch.

Fig. 2 shows details of the clutch. It also shows the maple friction blocks carried by a "spider" similar in form to a dished wheel, the dish of which may be varied somewhat. When the weight of the friction drum, together with that of the wire drawing block, is lowered on the wood friction blocks there is a tendency to force the "dish" out of the "wheel," causing expansion at the "rim" (friction surface); this force is sufficient to cause the friction to take hold. In other words the toggle action of the "spokes" forces the wood blocks against the friction surface on the inside of the drum (shown at the left in Fig. 2) with sufficient pressure to produce the necessary driving friction. The friction drum carries two pawls which engage the teeth on the inside of the wire drawing block; thus the vertical driving shaft can only produce rotation of the block in one direction.

Mechanical Safety Device.

Fig. 3 shows a bail or yoke shaped lever extending around the die bracket through which the wire is drawn; this bail shaped lever operates an air valve which turns air into or out of two single acting vertical air cylinders placed on opposite sides of the bench.

A forward push on the bail turns air into the two cylinders, producing an upward movement of their plungers and lifting the weight of the friction drum and block off the rotating toggle friction wheel, thus disengaging the clutch and stopping the wire drawing operation instantly, since the inertia of the moving parts above the friction is not sufficient to draw the wire through the die to any appreciable extent.

This is a very quick acting safety device. In event an operator should accidentally become entangled in the wire as it is being drawn through the die, on the instant his body or any part of it bringing slight pressure against the bail the clutch is instantly disengaged, affecting a very sudden stop of rotation of the block.

However, the performance of this safety device depends entirely upon maintenance of air pressure in the line and in event of failure the block must be stopped either by pressure on the foot lever (shown in the extreme lower position in Fig. 3) or by stopping the driving motor at the end of the line shaft which drives the 40 blocks of one bench. Stoppage of the motor in every case is affected by pushing a button; just how this is accomplished will be shown later.

Drives.

For the drives of benches Nos. 1, 2, 3 and 4 we have identical motors designated by our numbers 506, 507, 508 and 509 respectively.

These motors were furnished by Crocker-Wheeler Company. They are size 336-D, 300-hp., 230-volts d.c. shunt wound, 12 pole, 72 rpm. machines and each is

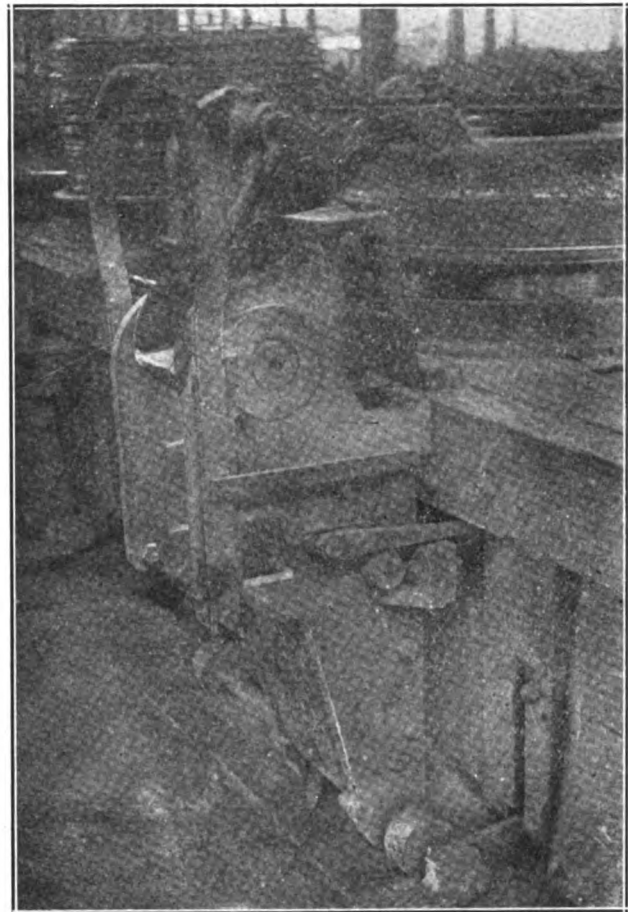


Fig. 3.

direct control to one of the bench line shafts by a flange coupling.

One half of this coupling has a 12-in. diameter bore for the armature shaft and the other half is bored 5-5/16 inches to fit the line shaft, which extends throughout the length of the bench, about 175 feet. Fig. 4 shows motor No. 508 which drives No. 3 drawing bench.

Starter.

This pictures gives a good view of the manually oper-

ated starting panel used with this motor; starters similar to this are also used in connection with the motors driving benches Nos. 2 and 4.

At bottom of the panel is shown 10 knife switches which must be closed by hand, one at a time, in proper sequence, to cut out the successive resistance steps used in starting the motor. At the top of the panel is shown the two line circuit breakers, one or both of which may be opened for stopping the motor. Between the circuit breakers and above the ammeter is shown a relay, the plunger of which is normally held up against gravity, thus bridging across two contact posts through which energy is supplied to the low voltage coil of one of the

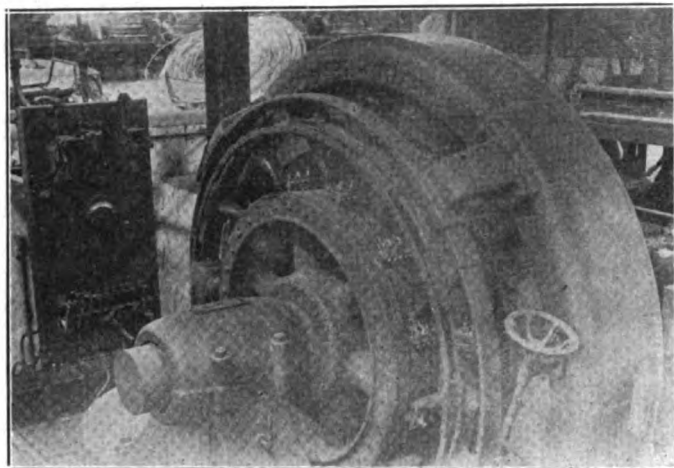


Fig. 4.

circuit breakers. The other circuit breaker is equipped with a shunt trip coil which is energized through a pair of contact posts which are short circuited by the relay when the plunger is down.

Stop Button.

Located on each of the 10 columns at 20-foot intervals near the bench are push buttons, any one of which when pushed will open the circuit through the relay coil, permitting the plunger to drop, thus effecting the operation of the low voltage trip on one breaker and the shunt trip on the other, as above explained. Of course, opening of either circuit breaker will, ordinarily, stop the motor. The several stop buttons are for use in event a man should get caught in the wire and be drawn in by it.

However, due to the characteristic toggle lever construction which is employed for mechanically holding the circuit breaker closed, there is always a chance that the breaker may fail to open in response to the touch of a button.

Starter for No. 1 Bench Motor.

In connection with the motor driving No. 1 bench, there is a magnetic switch starter which was assembled from factory made units; this starting panel carries four line contactors, two on each side of the line; two overload relays; a knife switch for the shunt field and control wiring; and one ammeter.

Since the line contactors are held closed by a circuit which may be interrupted by any one of the ten push buttons on the columns it seems impossible that they could fail to open at the touch of a button.

This starter has never failed to stop the motor instantly at the touch of a button and will also automati-

cally handle the accelerating switches in proper sequence every time.

Failure in the performance of this latter has often resulted in burnt spots on the commutators of the manually started motors. Sometimes in starting up with the old knife switch starters, the motor inspector will inadvertently close the circuit breaker without having previously opened all the knife switches; this usually produces the burnt patches on the commutator as above noted.

Drives of Benches Nos. 5 and 6 Motors.

Each of these benches is driven by a type M T, frame 412, 400-hp., 450 rpm., 2,200-volt, 3-phase, 60-cycle, form

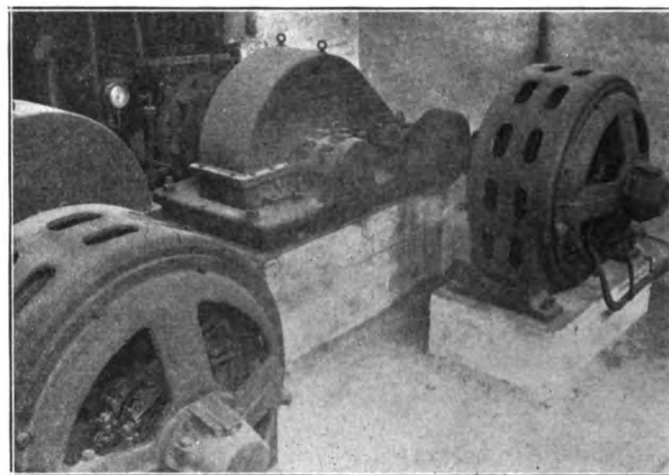


Fig. 5.

B, slip ring induction motor, furnished by General Electric Company.

Gearing.

The drive is through a Fawcus Machine Company's reducing gear unit, giving a reduction from 450 hp. to 72 rpm., or a ratio of $6\frac{1}{2}$ to 1 between motor and drive shaft.

Couplings.

The coupling between the rotor shaft and the gear unit is No. 22 Francke flexible coupling bored in one-half 5 in. for the rotor shaft and in the other $5\frac{1}{2}$ in. for the Fawcus gear shaft.

The coupling between the Fawcus gear and the bench line shaft is of the endless belt type and was manufactured here; Fig. 5 shows this coupling the No. 5 drawing bench. The bore in one half of this coupling is $6\frac{13}{16}$ in. for the Fawcus gear shaft and that in the other half is $5\frac{15}{16}$ inches for the bench line shaft. Each of these cast steel half couplings carries six $2\frac{1}{2}$ in. diameter pins which project $6\frac{1}{2}$ in. from the face; these pins are taper fitted and are held in place by a nut. The belt used in the coupling is three-ply leather, $6\frac{1}{2}$ in. wide.

Control.

The control apparatus for the two motors, numbers 535 and 536, is all housed in a two-story brick building, seven feet wide by 18 ft. 4 in. long, inside dimensions. The secondary panels, which form the main part of the magnetic control equipment, are assembled as one continuous switchboard and located on the upper floor of the building. This board is 6 ft. 4 inches high by 16 ft. long. As the equipment carried on this board is all in

duplicate a list of that required for one motor will suffice.

Panel 1 carries the following equipment:

- 1 three-phase, 2-coil indicating wattmeter.
- 2 inverse time limit overload relays, plunger type.
- 1 main oil circuit breaker, T. P. S. T., 4,500 volt, 200 amp., with overload trip coils.
- 1 undervoltage release.

Panel 2:

- 3 current limit relays.
- 1 D. P. S. T. 60 amp. control switch, with enclosed fuses.

Panel 3:

- 1 double pole, 75 amp. under voltage protective contactor.
- 2 triple pole, 150 amp. magnetic contactors.

Panel 4:

- 3 triple pole 150 amp. magnetic contactors.

Panel 5:

- 1 triple pole 150 amp. magnetic contactor.
- 1 triple pole 300 amp. magnetic contactor.
- 1 triple pole 600 amp. magnetic contactor.

The 600-amp. contactor is the only one of the eight triple pole switches which remains closed after the motor has been brought up to speed.

A view of the interior of the lower story of the control house is shown in Fig. 6. The magnetically operated oil immersed high voltage contactors, both front and rear views of which are shown, are for making and breaking the circuit through the motor primaries. These units were intended for reversing service, but since this feature is not needed in this case, the connections were made so that the motor runs forward when either one of the duplicate switches is closed.

In Fig. 1 a close up view of the master switch lever handle together with the maximum torque push button is shown located on the wall of the motor pit. The mas-

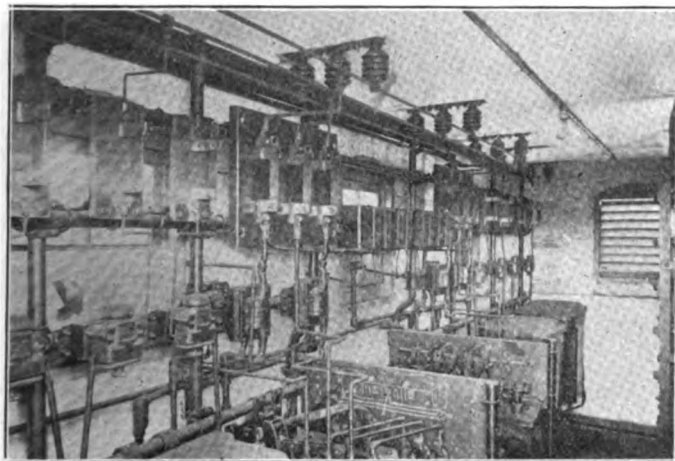


Fig. 6.

ter switch, or hand controller, has six points forward and reverse, which may be used in accelerating the motor by hand, or the lever handle may be thrown at once in either direction and the magnetic starter will automatically take care of the acceleration. The motor runs forward in this case regardless of whether the control-

ler handle is moved to the forward or reverse position. The "maximum torque button" is for use in event the motor may not develop sufficient torque to start with all the resistance in circuit with the secondaries; a touch of this button will close the third accelerating contactor and thus insure starting under conditions of excessive load.

Safety Stop Buttons.

For each of the motors driving benches 5 and 6 there are two stop buttons; those for No. 5 bench are located on columns near each end of the bench; in the absence of

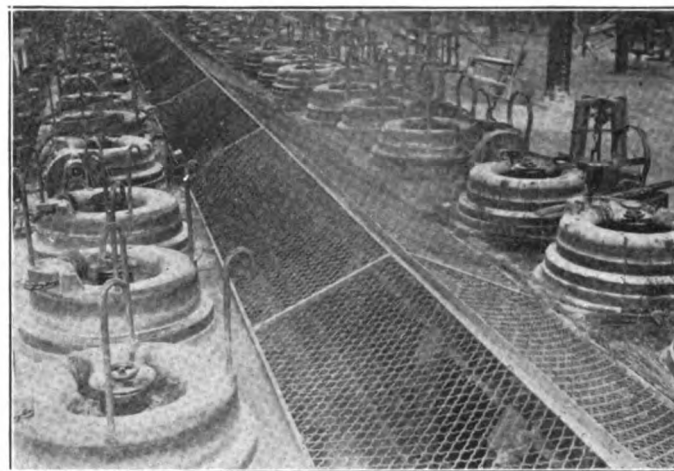


Fig. 7.

columns along the side of No. 6 bench the two push buttons, one near each end of the bench, are each operated by a chain suspended from a lever supported by the roof truss overhead.

Pressure on one of these buttons opens the circuit through the coil of the under voltage contactor on panel 3 and this causes all switches to open instantly, stopping the motor, which will not start again until the master switch handle is returned to the "off" position.

The off position of the master switch serves to reset the under voltage protective contactor, and when the motor stops from any cause it cannot be started again until the master switch is returned to this position.

FRACTURE OF WIRE IN STEEL ROPE.

This was the subject of a paper recently read before the British Association by Dr. E. M. Horsburgh, in which the principles of examination and possible solutions of rope problems were involved. One section deals with the system of forces across a rope section, as compared with the forces in system of flexible cords sustaining a load. Another section deals with the rope modules and a method shown whereby an analytical expression might be fitted to curves. Other matters touched upon were the aggregate strength of rope wires, also experiments in combined stresses re tension with bending and with torsion. Attention was also drawn to fatigue tests, and mathematical grounds were given for inferring the existence of a fatigue stress. An instance was quoted, where, in the case of a rope which failed after $2\frac{1}{2}$ years service, the unstressed and stressed portions were annealed, from which conclusive evidence was obtained of fatigue of the wire, and that the fracture was not due to sudden stress.

American Rolling Mills For France

Description and Layout of the Mills Recently Constructed by the United Engineering & Foundry Company and Shipped to the Acieries de la Marine et Homecourt of France.

AMERICAN Rolling Mill Practice is rapidly being adopted by France. Heretofore, the majority of French steel works produced a very wide range of products, the average order for each kind of product being small. On this account, the mills had to be adopted for this class of production and were mostly what might be called the jobbing variety. In other words, their problem was one calling for a variety of production rather than a large tonnage production.

binning, they were enabled to devote entire plants to the production of a few lines of product—in other words, not only specializing mills but also specializing plants. A good example of this is contained in the Acieries de la Marine et Homecourt, France, wherein the Homecourt Plant will be devoted entirely to plates

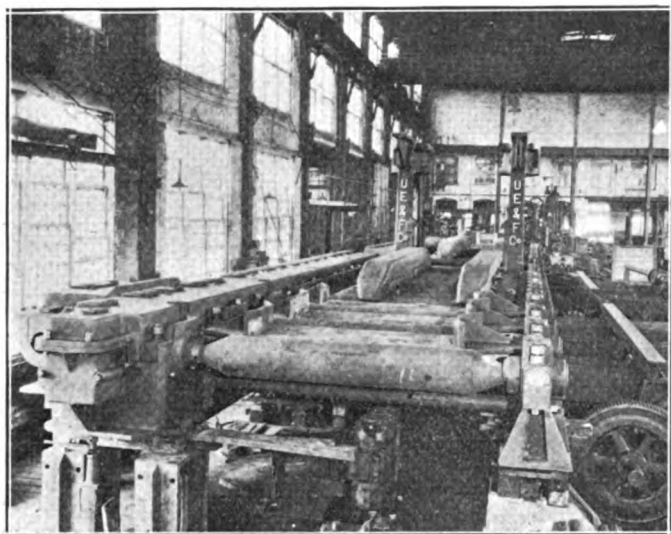


Fig. 1.

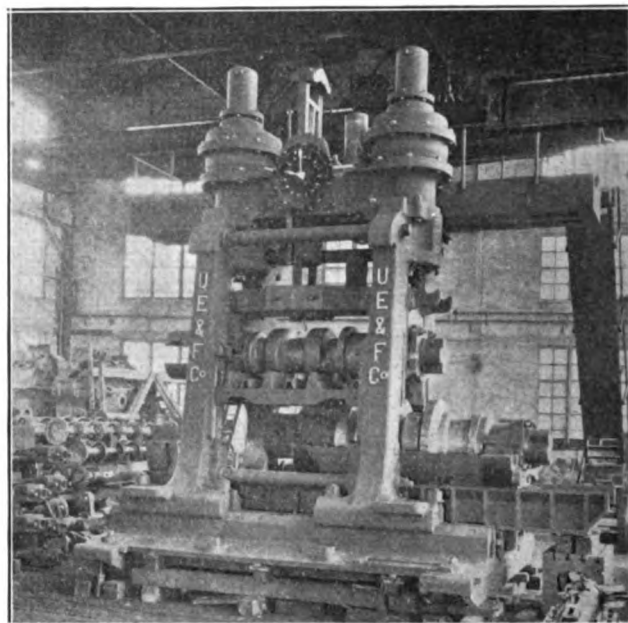


Fig. 2.

Since the war, France has acquired approximately one-third of the iron ore reserves of Europe. In order to take advantage of this situation and to promote as rapidly as possible the prosperity of France they are changing their methods and introducing specialty or tonnage mills. Instead of working independently, many of the steel plants of France have combined so as to avoid competing with each other. By this com-

and small billets while the Micheville Plant will be devoted almost entirely to rails and structural material.

In 1919 this French combination placed with the United Engineering & Foundry Company of Pittsburgh, Pa., orders for five separate and complete units. For the Homecourt Plant 1—44 in. Blooming Mill and 1—48 in. Universal Plate Mill. For the Micheville

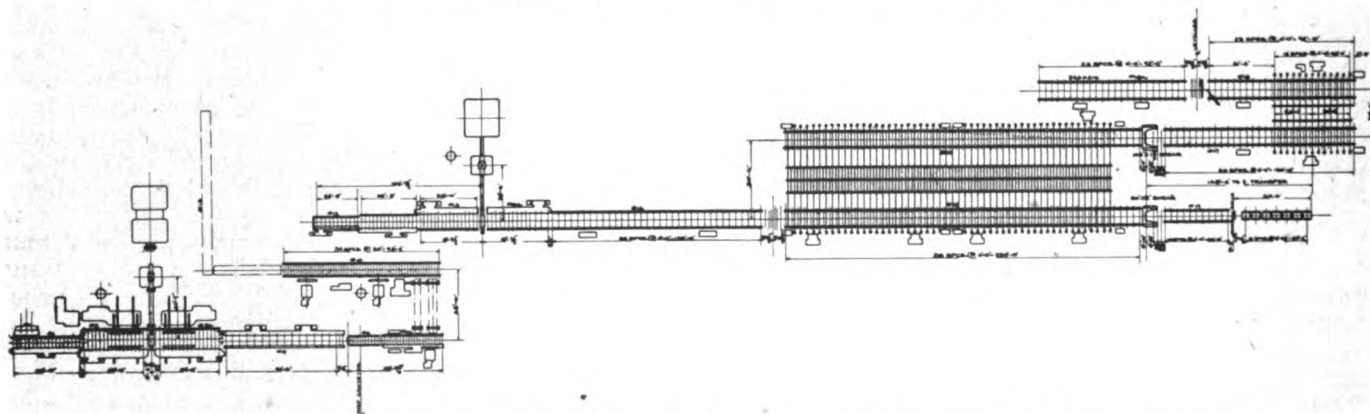


Fig. 3—The general arrangement of the 44 in. blooming and 48 in. universal mill for Homecourt.

Plant a 44 in. Blooming Mill, a Combination Rail & Structural Mill and a Cross Country Light Structural Mill. The mills for Homecourt are shown on small scale layout. The machinery is of the most modern type. The Blooming Mill is a 44-in. Reversing Type, a most noteworthy feature about it being its ability to roll slabs 50 in. wide. This Blooming Mill will roll slabs for a 48-in. Universal Mill and for a number of Plate Mills to be built in the future ranging from 84 in. up to 132 in. It will also roll blooms for a Morgan Continuous Mill.

The question of lubrication has become a very important one in recent years and the mill tables on this mill were designed especially with this end in view. Figure 1 shows the front and back mill tables being erected in the shop. By examining the photograph, you will note that the line shaft, gears and bearings are all enclosed in an oil tight case. The oil is pumped

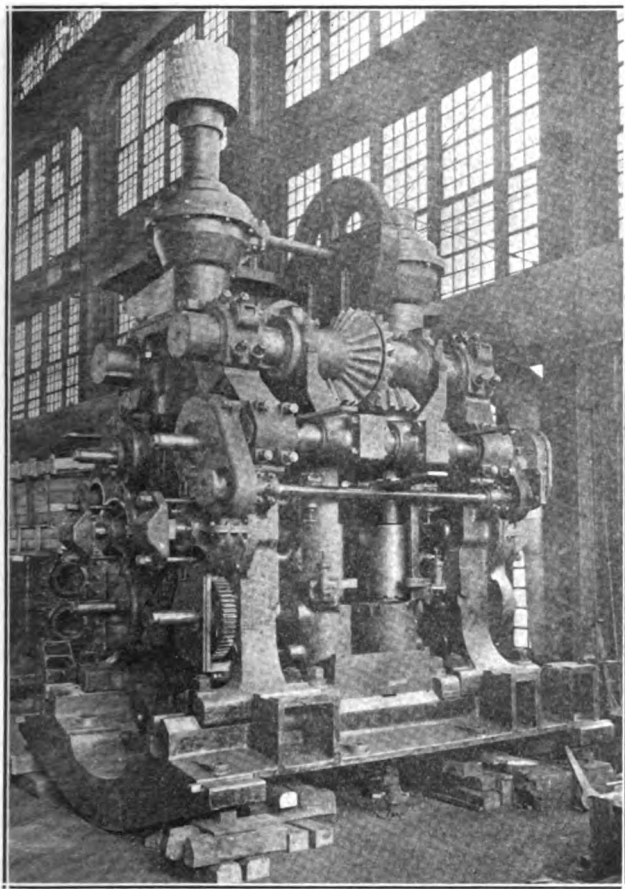


Fig. 4.

through piping to each bearing and set of gears. After lubricating the parts, the oil is collected and returned to a filtering tank where it is cleaned and used over again.

The 48-in. Universal Mill is of the 2 High Reversing Type and is shown on Figure 4. It was designed to cover a wide range of universal plate and will roll these in sizes from 11 in. to 48 in. wide. It was also arranged to be used as a reversing plate mill. The vertical roll attachments were especially designed for rapid removal so that the mill could readily be changed from a universal to a sheared plate mill.

The layout of the auxiliary machinery for both the blooming mill and the universal mill are indicated on

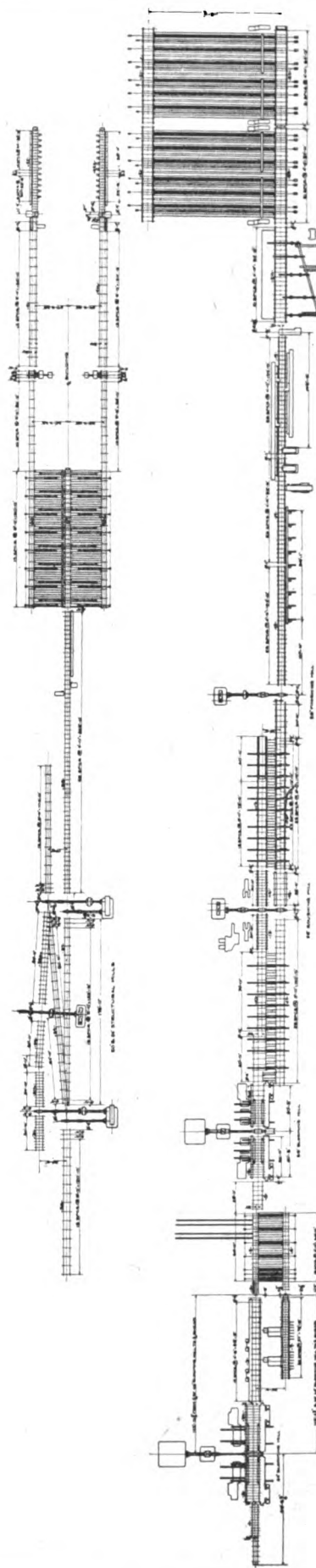


Fig. 5—General arrangement of the 44 in. and 36 in. blooming mills and 28 in., 20 in. and 24 in. structural mills for Micheville.

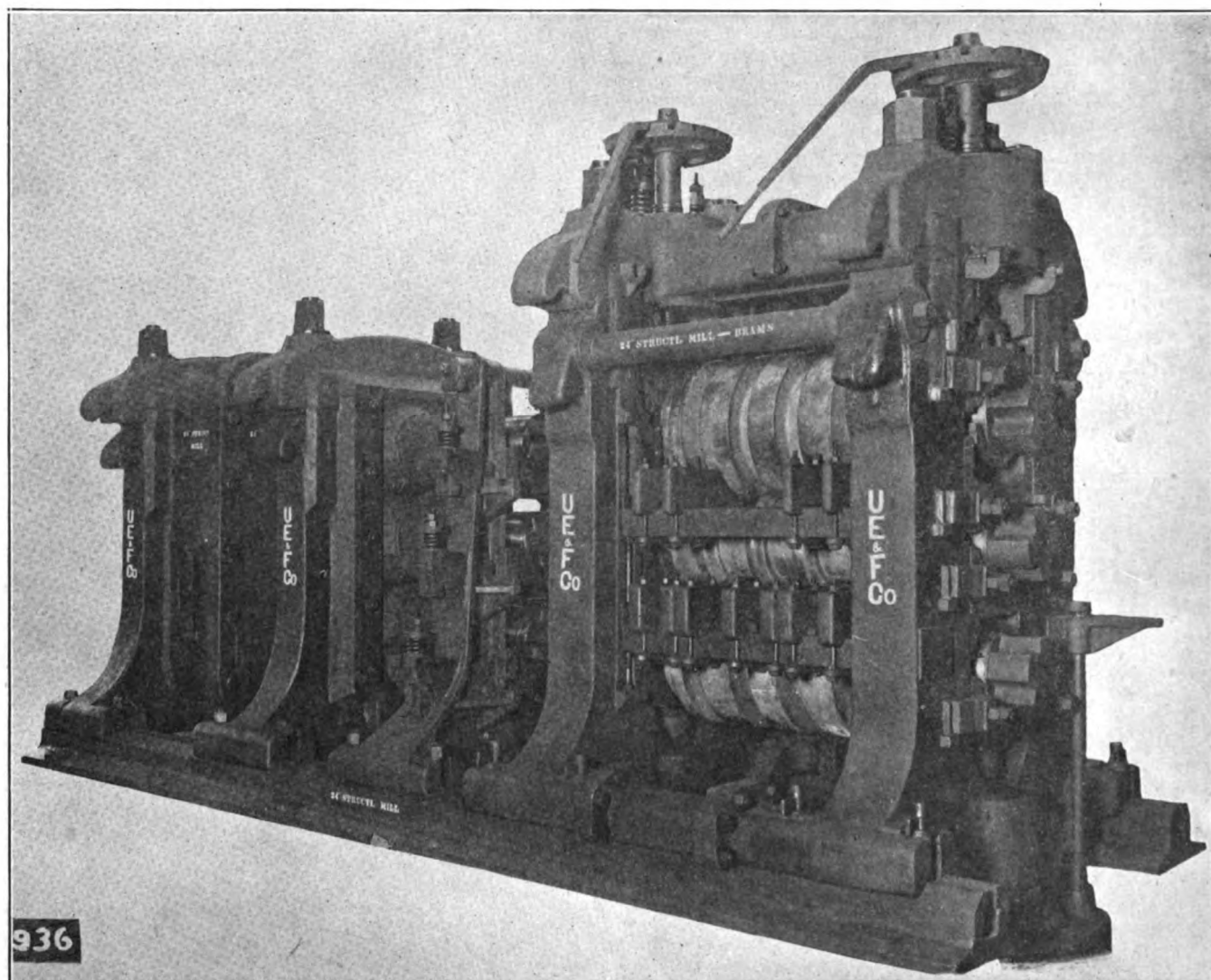


Fig. 6—General construction of light structural mills.

the small plan. The structural mills for Michewille are shown on the small scale layout. The blooming mill is a 44-in reversing type, duplicate of the one for Homecourt with the exception of the shear and bloom handling equipment. The combination rail and structural mill which is set tandem to the 44-in. blooming mill consists of a 2 high reversing 36-in. roughing stand, 28-in. 3 high stands of rolls and 1 stand of 28-in. 2 high finishing rolls. The general design of the 44-in. blooming mills and 36-in. roughing mills are shown on Figure 2. They all consist of the "United" Patent A Frame Housing. The 36-in. roughing mill possesses one feature different from the blooming mills and that is the method of changing rolls. On account of being used as a roughing stand for rail and structural material, the bottom roll must have very large collars. It has been the past practice to make roughing mills of this type with removable caps or else the windows of the mill had to be very wide in order to remove the rolls. By the construction shown in the illustration it was possible to use a solid top housing and a mill with a very narrow window. The bottom part of the window has an opening large enough to allow the roll to pass through. The roll is shown mounted in its bearings, partly withdrawn from the mill. By this construction, a simple, sturdy mill is obtained, rapid

roll changing is accomplished, short roll lengths are permitted because several passes can be taken through the same groove in the roll due to the fact that the top roll can be adjusted for each pass by means of the screwdow. The 28-in. mills are equipped with all the latest handling and manipulating devices that have been invented up to the present time for the rapid and automatic handling of rail and structural materials. The light structural mill consists of 1—3 high stand of 24-in. rolls, followed by a 2 high 20-in. edging stand, followed by 2—3 high stands of 20-in. rolls, followed by 1 stand of 2 high 20-in. finishing rolls. The 24-in. stand is equipped with lifting tables and "United" Automatic Manipulator. The general type of the mill is similar to the one installed at the Clairton Steel Company in this country. It is equipped with double hot bed and double finishing end for the rapid handling of light structural material. Angles, flats, small beams and channels will be its principal products. The mill is also arranged to roll light mine rails 40 lb. and under. The general construction of the 28-in.—24-in. and 20-in. mills are as shown in Figure 6. The rolls and guide equipment was furnished complete. All of the auxiliary machinery, such as tables, transfers, shears, hot beds, levelers, etc., were designed and built complete.

The Mansfield Sheet and Tin Plate Company's New Steel Unit

This Company Is Now Completing Its Steel Making Plant Consisting of Four Open Hearth Furnaces, Soaking Pits, a 32-Inch Mill and a 24-Inch Sheet Bar Mill.

By CARL W. PEIRCE*

ABOUT seven years ago the old National Rolling Mills Company at Mansfield, Ohio, was taken over by W. H. Davey and his brothers, remodeled and in three months time was engaged in the manufacture of steel sheets under the name of the Mansfield Sheet & Tin Plate Company. The old concern, which consisted of three hot mills, housed in a building 67x140 feet, had only operated for a few months before it was compelled to shut down and never operated afterward as the National Rolling Mills Company.

Under the management of Mr. Davey and his seven brothers, all of whom were practical sheet mill men, the new company was successful from the start.

From time to time additions were put onto the old plant so that today the building is 167 feet wide by 940 feet long and houses seven tin mills with their accompanying equipment.

Early in the year 1917 ground was broken for a new sheet mill unit which was located south of the old plant and on the other side of the Pennsylvania railroad tracks between the railroad and Bowman street. This plant, which was built mainly for the manufacture of high polished sheets, was designed and built under the supervision of Mr. Austin Davey, chief engineer of the company. The building, which houses 12 sheet mills with their pickling, annealing and cold roll departments, is 226 feet wide by 1,039 feet long. This plant was put into operation in the fall of 1919.

On account of its inability to get a satisfactory delivery of sheet bars, the company in the fall of 1919 began to consider the advisability of building their own steel making unit. A piece of land lying between the B. & O. and Pennsylvania railroads and joining the company's property was occupied by two hills which it was necessary to remove. It was selected on account of its railroad connections and its proximity to the other two parts of the plant.

In March, 1920, the Fred R. Jones Construction Company with three steam shovels started to prepare the site for a steel unit large enough to produce what bars the sheet and tin mills would consume and the work of designing the unit was begun. This work was done by Mr. F. A. Davey, chief engineer, and Mr. Carl Pierce, open hearth superintendent, with Mr. Frank I. Ellis of Pittsburgh as consulting engineer. Mr. J. Coursin was in charge of the field work.

Plans were drawn for an open hearth of four 80-ton furnaces with covered stock houses and a rolling mill department consisting of soaking pits, a 32-inch

mill for breaking down the ingots and a 24-inch sheet bar mill. On account of the product of the mills being mainly high polished sheets, it was the desire of the president of the company that the steel should be poured by the bottom-cast method in order to guarantee a high grade sheet bar.

The general layout plan shows the relation of the steel plant to the tin mills and of the open hearth and rolling mill units indicating in dotted line the future furnace extensions.

In view of the peculiar shape of the land it was early decided to leave a part of the hill on the west side of the property and place the stock yard upon it, bringing it on a level with the open hearth charging floor and parallel to that building. In making the crossovers from the stock yard to the open hearth a new arrangement has been used. Instead of pulling out from the end of the stock yard and entering the charging floor at the ends, a double crossover track extends from each end of the stock yard and crosses to the opposite end of the charging floor, the crossovers connecting with the furnace track between furnaces Nos. 1 and 2 and between 3 and 4. The advantage of this type of construction is that the stock yard engine is able to deliver a drag of loaded pans on the furnace track over one crossover, then back down the floor and remove the empty pan cars to the stock house over the other crossover, performing the two functions by the one shift. By this arrangement, too, it is impossible to have a furnace blocked from charging because another furnace between it and the stockhouse inlet is being charged, as the charge can come in over the other crossover.

The buildings furnished by the McClintic-Marshall Company are of strong, sturdy construction in keeping with the other equipment of the plant. In the stock yard building, which is 77 feet wide by 300 feet long, is a 20-ton crane for loading the charges. The first two bays at the south end of this building are occupied by large concrete bins for the storage of limestone, raw dolomite, and iron ore. Two tracks run through the east side of the building, the one nearest the open hearth being used for loading the charging pans and is on a level with the charging floor; the other track used for loading is four feet lower. This arrangement brings the tops of the gondola cars of scrap and the charging pans on the same level. This latter track being four feet lower than the loading track decreases by this amount the grade of the track leading from the mill level into the stock house. On the brow of the hill outside the stock house and between it and the open hearth are two tracks, one being used as a storage track, the other nearest the stockhouse as a run around track in going from one end of the stock

*Mr. Peirce is open hearth superintendent for the Mansfield Sheet & Tin Plate Company.

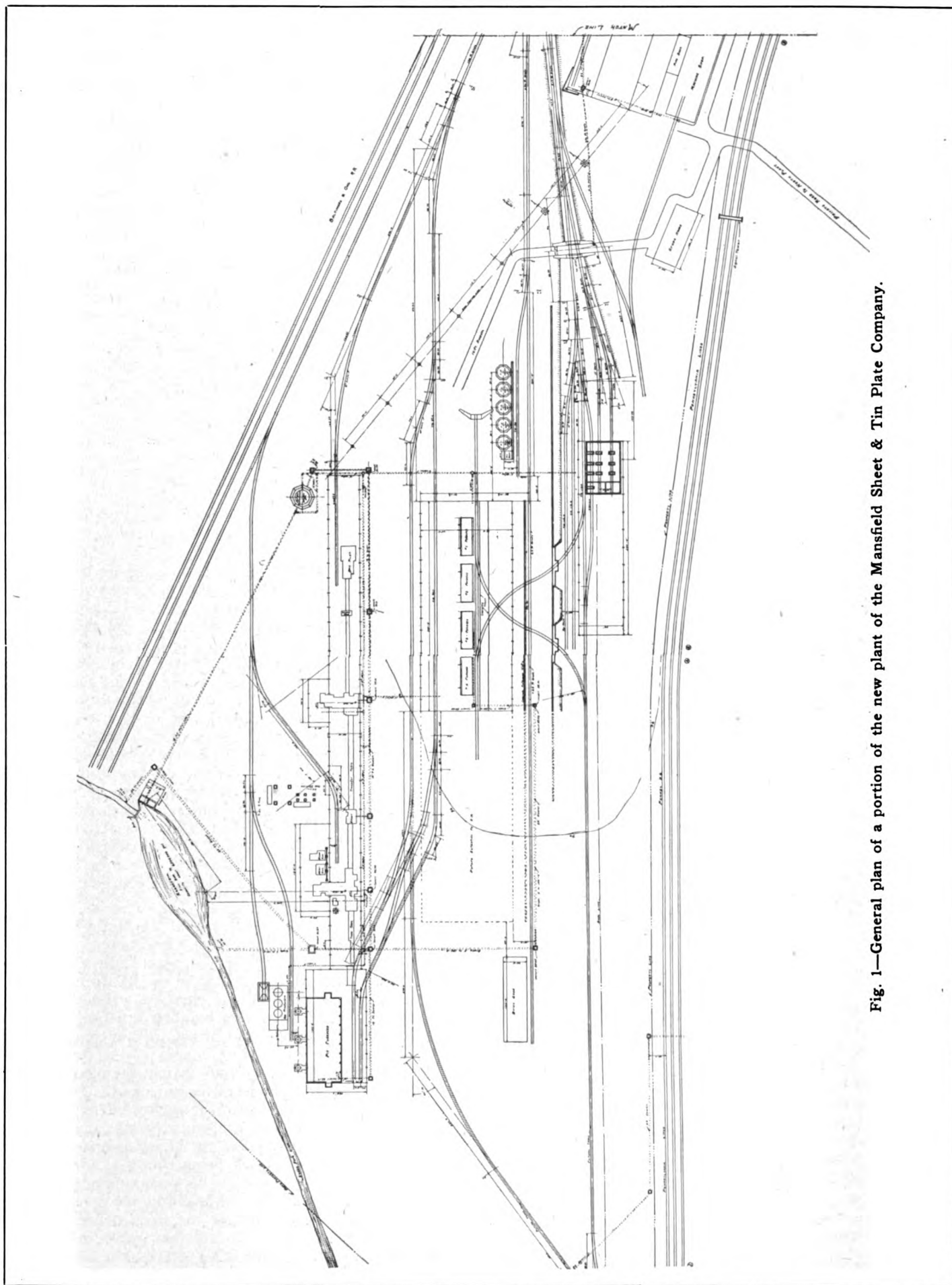


Fig. 1—General plan of a portion of the new plant of the Mansfield Sheet & Tin Plate Company.

house to the other. A 75-ton two-section scale with self-indicating Weightograph attachment furnished by the Buffalo Scale Company, Buffalo, N. Y., and located on the loading track midway between the crossovers will weigh all charges. A 150-ton 4-section railroad track scale, furnished by the same company, is located in the yard between the north plant and the B. & O. railroad. The charging pan and ingot cars, furnished by the Pittsburgh Steel Foundry Company, are of skeleton steel casting type equipped with Hyatt Roller bearings and with a patent coupling device designed by the foundry company. These cars, in addition to all mill cranes and run out tables, will be lubricated by the Adkins Lubricating System, Canton, Ohio.

Between the stock yard building and just outside the valve cellar wall of the O. H. is a depressed track to allow for passage of cars under the crossover tracks leading from the stockhouse to the O. H. Space has been left on the mill level between the depressed track and the stock house for a future installation of gas producers. The depressed track also permits the wheeling of dirt directly onto the cars when the furnace regenerators are cleaned or for the removal of ashes from the gas producers.

The open hearth building housing the four 85-ton furnaces is 360 feet long, with a pouring aisle 65 feet wide and a 25-foot leanto over the valve cellar. The charging floor which is 16 feet above mill level has its furnace track 6 ft. 6 in. center from the front of the furnace, permitting the passage of standard gauge cars over it. This arrangement permits the dumping of iron ore and limestone through the tail trestles at each end of the charging floor and will permit the unloading of a car of brick at a furnace when it is under repairs.

The 85-ton O. H. furnaces which are being built by the S. R. Smythe & Company, Pittsburgh engineers and furnace builders, are at 80-foot centers in the building and are 65 ft. 3 in. long over the brickwork, having a hearth 15 ft. by 35 in. by 5 ft. deep. They have been designed to burn either oil or natural gas as fuel. They will be started out on oil, five 100,000-gallon tanks having been provided for oil storage. The furnace hearths are supported upon two piers 8 ft. 7½ in. by 17 ft. 7½ in. by 15 ft. 3¼ in. high placed 19 feet apart. These piers are made of 18 inches of wire cut brick on the outside and the center filled with concrete. On these piers are placed ten 20-in. 80-lb. beams with 12-in. cross channels, the channels forming the bottom of the pan upon which the hearth is built. The chills at the end of the hearth are made of plates and angles properly braced.

The buckstays supporting the hearth and roof are made of 15-in. beams and channels, the latter reinforced by one-inch plates riveted to them. The front and back of the furnace pan between the buckstays is made of heavy iron castings properly ribbed. The door castings are designed with the front corner cut away for the installation of a 4-inch water line to care for the waste water from the doors, this arrangement providing for a very short connection from the door to the telescope pipe.

The port-ends and regenerators are bound with 12-in. beams and channels properly reinforced. The furnace regenerators are 22 ft. 10½ in. long and 9 ft. high from the top of the rider walls to the square of the arch, the gas chambers being 7 ft. 1½ in. and the air chambers 12 ft. 10½ in. wide with a 3-foot wall between them. The flues leading from the regenerators to the valves are of the standard design for 36-in. gas and 42-in. valves of the Blair Engineering Company design with which the

furnaces are equipped. Waste heat boilers of 500 hp. each and built by the Erie City Iron Works, Erie, Pa., have been installed on furnaces Nos. 3 and 4, for utilizing the heat from the waste gases from the furnaces, 60-in. Blair valves making the connections between the furnaces, the boilers and the stacks. Mechanical draft for the boilers is furnished by 7 ft. 6 in. Sturtevant fans driven by steam turbines. The fans and turbines are located on the lean-to floor adjoining the boilers.

The furnaces are provided with five electrically operated charging doors of the Knox water-cooled type, the middle door opening being 48 in. wide by 45 in. high, the others being 42x42 in. The motors and drums controlling these doors are located on platforms underneath the charging floor and just back of the regenerators.

A 5-ton high type charging machine of Alliance Machine Company make with track span of 14 ft. 6 in. has been installed to charge the furnaces. This machine is designed with a two-foot clearance between the charging rails and the lower framework of the machine. The furnace aisle has been designed for the future installation of an overhead crane.

The charging floor between the furnaces slopes gradually to the platform behind the furnaces which is on a level with the tapping hole platforms. Six-ton electric jib-cranes furnished by the Pittsburgh Crane & Equipment Company are at the back of each furnace for the removal of the tapping spots, which are of the V-shaped steel casting type.

On account of the steel being poured by the bottom cast method, the pouring aisle is traversed by only one track which will serve alike for the removal of ingots to the pits, the east side of the building, on the floor in front of which are placed the pouring plates. These plates are 8 ft. 4 in. square and designed to permit the pouring of 12 14x15-in. ingots from one fountain. Five plates will be required to handle the output of each heat, the two pouring platforms being long enough to accommodate 25 pouring plates. Between the two platforms is a hydraulic stripper for pushing out sticking ingots. This stripper is equipped with a motor driven pump, making it a self-contained unit. The 90-ton ladles of modern design with sloping bottoms and the nozzle at the lowest point were made by the Treadwell Construction Company, Midland, Pa.

The pouring aisle is provided with a 125-ton main hoist ladle crane with a 25-ton auxiliary trolley, and a 5-ton stiff-leg crane of the soaking-pit type, both of Alliance Machine Company make. The stiff-leg crane was designed to be able to strip molds from the ingot, twist the latter from the bottom roots and pile on the cars for delivery to the soaking-pits in addition to setting the molds back on the pouring plates. This method of handling bottom-poured ingots guarantees their delivery to the soaking-pits as quickly as though they were top-poured.

The overflow of slag from the ladles will be caught in large steel casting boxes of the truncated pyramid type, having a capacity of 165 cubic feet and placed on the floor alongside the ladles. After the slag is sufficiently cooled for transportation, the box with its contents is placed on a specially designed side dump car large enough to hold one slag chunk, the box is then stripped from the chunk, leaving it on the car ready for transportation to the slag dump. The small dirt will be handled in 12-yard side sump cars. A grinding house with heavy duty 9-foot pan is on the mill level and joins the pouring aisle at the south end.

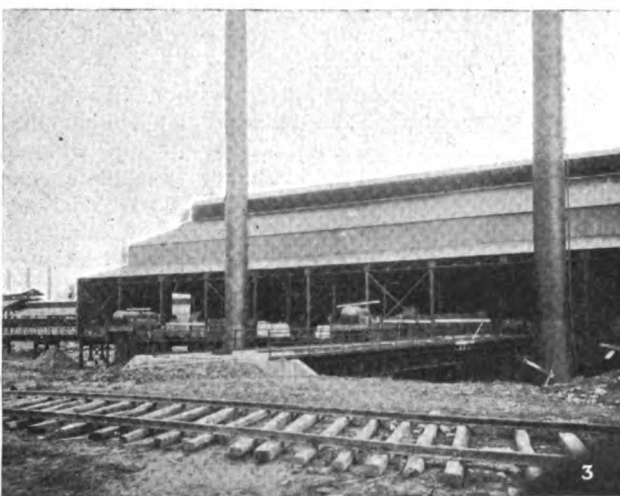
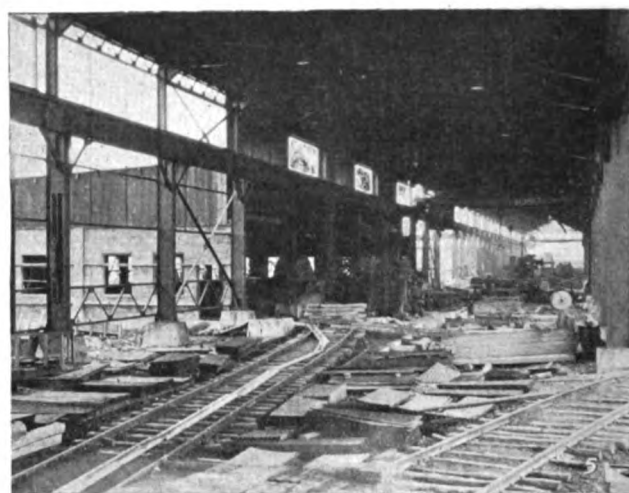


Fig. 1—Stock house, open hearth building and rolling mill building.

Fig. 2—View of mill building showing stand pipe under erection and soaking pits and gas producer buildings in background.

Fig. 3—View from stock yard scales showing one of cross-overs, waste heat boilers and soaking pit and mill buildings in background.

Fig. 4—View of mill showing bar piler in foreground, 1"x8" shear, and 24" slick mill in background.

Fig. 5—View of interior of the mill building.

Fig. 6—View through bar mill building before starting the erection of mills.

At the south end of the pouring aisle and at a level with the top of the crane girders is a repair platform, arrangements having been made for the future installation of a mono-rail and crane for serving cranes in both the charging and pouring aisles. An escape platform has been provided for the ladle crane operators above the pouring platform and on a level with the crane cab, extending the entire length of the building. This platform has a runway outside the building with steps leading to the ground to allow operators to escape in case of a bad spill.

From the pouring aisle, the ingots are taken to the soaking-pit building which with the mill building lies to the east of the open hearth and runs parallel to it, a space of 100 feet separating the open hearth and mill buildings. The soaking pit building, which is 192 feet long by 77 feet wide, and with a 20-ft. lean-to over the valve cellar, houses three pit furnaces of four holes 5 ft. 6 in. by 8 ft. each, built by the Smythe Company. The arrangement of the pit holes is opposite to that of the usual design, the 12 holes being in line with the length of the building, the covers being designed to back into the lean-to building when open so as to be out of the way of possible damage from the crane. This arrangement also permits the use of a tunnel running under the line of the 12 pits, which is served by track, slag cars and boxes. Between each two pits is an opening for the removal of the slag boxes by the crane. The pit covers are operated by a special design of a shaft driven by a motor with a separate clutch for each cover. By this arrangement one motor will operate the four covers of each furnace. These furnaces are designed to operate without regenerating the gas, no checkers being placed in the gas chambers and all outgoing gases passing through the air regenerators. These furnaces are very strongly reinforced with three sections of 20-in. beams with 9-in. vertical channels. The bottom structure of the pit holes consists of 2-in. cast iron plates resting on 12-in. beams. The valves are of the ordinary butterfly type. The stacks are self-supporting and are 4 ft. 6 in. in diameter and 120 ft. high.

At the east of the soaking pits and at the rear of the stacks is a gas producer building housing three 10 ft. 6 in. stationary producers equipped with direct drive Chapman agitators built by the Chapman Engineering Company, Mt. Vernon, Ohio, which will furnish gas for heating the ingots. Over each producer is a large steel coal hopper of 50-ton capacity, served by a 5-ton Northern crane and grab bucket. The coal is delivered to the gas producers over a trestle from which it is dumped into a hopper, crushed and conveyed to a bin under the gas producer crane. The single roll crusher and belt conveyor are of standard design and built by the Webster Company, Tiffin, Ohio. Between the soaking-pit stacks and the gas house cellar is a depressed track which permits the wheeling of the ashes directly onto a side dump car.

In the soaking-pit building and to the west of the pits are three tracks, the two on the outside for the delivery of ingots from the open hearth and the one nearest the pits for the ingot chariot. This building is served by a 5-ton standard type soaking pit crane of Alliance Machine Company make. From the pits the ingots are carried by a motor driven chariot, built by the United Engineering & Foundry Company, and delivered on the approach table leading to the 32-in. mill which is of the 3-high type built by the Wm. Todd & Company, Youngstown, Ohio.

The motor driving this mill is a 2,000-hp. 240-rpm.

2,200-volt a.c. type of General Electric make, the power passing through a 20-ton flywheel, a 5 to 1 reduction gear built by the Morgan Construction Company, then through the pinion housing to the rolls, the hydraulic lift tables are operated by an Aldrich 600-lb. pressure pump and accumulator, the table on entering side being served by a manipulator car with fingers for turning the ingots.

The 14x15-in. ingots will be reduced in 11 passes, the last an edging pass to 2½x7¾-in. bars, after which they pass to an 8x8-in. motor driven Mesta shear, from which the cut bars pass to a 24-in. Slick patent sheet bar mill made by the United Engineering & Foundry Company. The runout tables between these mills, the rolls of which are equipped with Hyatt roller bearings, were made by the Woodard Machine Company, Wooster, Ohio, and lubricated by the Adkins System, Canton, Ohio.

The 24-in. mill motor is of a 2,500-hp. 240-rpm. 2,000-volt a.c. type, also of General Electric make, the power passing through a 40-ton flywheel, then through the reduction gear and pinions to a 3-high stand in which the bars make four passes, being carried from the lower to the upper passes by a series of chutes which form the basis of the Slick patent. From the final pass in the 3-high the bars are shoved over to the final pass in the 2-high stand by a hydraulic arc. Both stands of rolls in this mill are in line and run by the one motor.

The bars after leaving the 24-in. mill are conveyed by pinch rolls and chutes to a 1x8-in. shear made by the Cleveland Punch & Shear Company and from there to a Kennedy bar piler made by the United Engineering & Foundry Company. Ample cooling beds occupy the space between the bar piler and the end of the building. The mill building, which is 850 feet long by 55 feet wide, is served by a 25-ton and a 10-ton crane of Alliance Machine Company make.

The control on all cranes has been furnished by the Electric Controller & Manufacturing Company, Cleveland, Ohio, the general control by the Westinghouse Company, all small motors and main switchboard by the Westinghouse Electric & Manufacturing Company. The yard work is served by a 20-ton, 50-ft. boom McMyler crane and a 40-ton saddle tank American locomotive. In the general layout of the plant, attention has been given to sewers, water and power conditions. A 36-in. reinforced concrete sewer into which empties two 24-in. sewers from the open hearth and mills and running west from the creek across the north end of the future extension of the open hearth will care for all waste water. A concrete dam with two 4-ft. flood gates has been placed in the creek near the B. & O. tracks, and the creek widened above the dam to accommodate a water storage of 6,000,000 gallons. In the pump house adjoining the dam are two 10-in. 2,000 per minute Manistee centrifugal pumps which pump the water through a 12-inch line to a 300,000 gallon standpipe located at the south end of the bar mill building. All water will be measured through a Venturi tube, giving an accurate estimate of the total water consumption.

In the 32-in. mill motor room has been installed a 600-kw. motor generator set of General Electric make and a 400-kw. steam generator set to insure sufficient power to operate all cranes in case the power should be shut off by our outside source of supply.

The output of the mill unit, which will consist mainly of high grade sheet bar for the manufacture of high polished sheets, will be approximately 10,000 tons of bars per month.

given to the elimination of hand labor by the substitution of machinery and labor saving devices. The location of the plant, too, is particularly well chosen as it has railroad connections with three trunk line roads, the Pennsylvania railroad, the the B. & O. and the Erie, and as it is the only steel making unit in the district

lying north of Columbus and between Cleveland-Canton on the east, and Gary, Ind., on the west, it has a marked advantage in freight rates on the steel scrap produced in this district. It is also close to its supply of pig iron, limestone and coal. Its operation should add much to the industrial life of Mansfield.

The Influence of Furnace Design on Quality and Cost of Product

THE ultimate cost of a finished product of given quality is governed by the cost of operation as influenced by the rate of production.

Because of the many variable factors governing the quality and cost of product, the selection of furnace equipment and the selection of fuel, consistent efforts to reduce cost of production require a thorough study of heat-treatment methods, manufacturing requirements and plant conditions.

The influence of furnace design on the quality and cost of product is illustrated by the diagrams which are example from actual practice.

These diagrams illustrate the economy attainable by the use of furnaces of improved design, the selection of which is based upon an intelligent study of the manufacturing problem as a whole. They also illustrate the economic weakness of the far too common practice of basing selection only on price or form of fuel, equipment or labor; quantity of output; temperature control, etc., without reference to other equally essential factors.

There are no fixed standards determining definitely the proper form of equipment or fuel. Each must be selected with reference to the other, and the combination adapted to the heating process, manufacturing requirements and plant conditions.

Frequently it is possible to better the quality of product by adapting an improved method of heating or cooling to existing conditions. A different type or arrangement of furnace equipment may decrease labor, fuel and time; utilize the floor space to better advantage; and provide more comfortable working conditions. This generally results in an increased output and lowered production cost even with the same unit prices for fuel, labor and power, without necessarily requiring new building construction.

Requirements for quality should determine the method of heat application. With this as a basis, the production requirements and plant conditions should determine the type, size, number and arrangement of furnaces; the form of fuel or electrical energy; and the methods of routing and handling the material.

It is a common but misleading assumption that control of chamber temperature or of heat supply is synonymous with control of heated product. On the contrary, control of the generation of heat is not equivalent to control of the application of heat, or to control of the uniformity of product. Other essential factors influence quality and ultimate cost of production.

The comparative ease of controlling electricity, gas or oil is frequently considered as the determinative factor in the selection of heating equipment, regardless of a material difference in price of other forms of heat energy or equipment.

Automatic control of the delivery of coal through stokers or in powdered form; of gases, oil or steam through automatic valves; or of electricity through various forms of regulating devices, may result in control of the generation of heat, but does not necessarily determine the use made of the heat.

The question of control involves: Control of supply of fuel to the furnace; control of supply of heat to the working chamber; and control of heat actually applied to the product. The influence of furnace design upon the application and utilization of heat in the product is far-reaching.

There is a radical difference between the arc, induction, and resistance methods of generating heat by electricity. There is even a distinction within each of these broad groups. With the resistance method, for example, the heat may be generated by means of metallic resistors distributed on the walls of the furnace or by other forms of resistance material the nature of which prohibit such distribution. In each instance the furnace design must be adapted to the method of generating and delivering heat to the working chamber.

It is thus apparent that the practice of associating a given form of fuel or electricity with quality or low cost of production is misleading, unless there is definite reference to the form of furnace and method of heat application.

This fact may be illustrated by an unusual case which involved a comparatively efficient type of furnace fired manually with bituminous coal, and three less efficient furnaces, one fired with oil, another with natural gas and the last heated electrically through metallic resistors with suitable control devices. With all other conditions alike, it was conclusively proved that the quality and cost of the product were most favorable with the coal-fired furnace.

This example, however, does not prove that any one method of generating heat is superior. In this instance the difference in results was due to the better design and operation of the coal-fired furnace, and the manner of applying and utilizing the heat. In one case, the apparent disadvantage of a crude form of fuel was overcome by an efficient furnace, while in the others the apparent advantages of the more flexible forms of fuel, and particularly the advantage of electricity with control devices, were neutralized by inefficient furnaces.

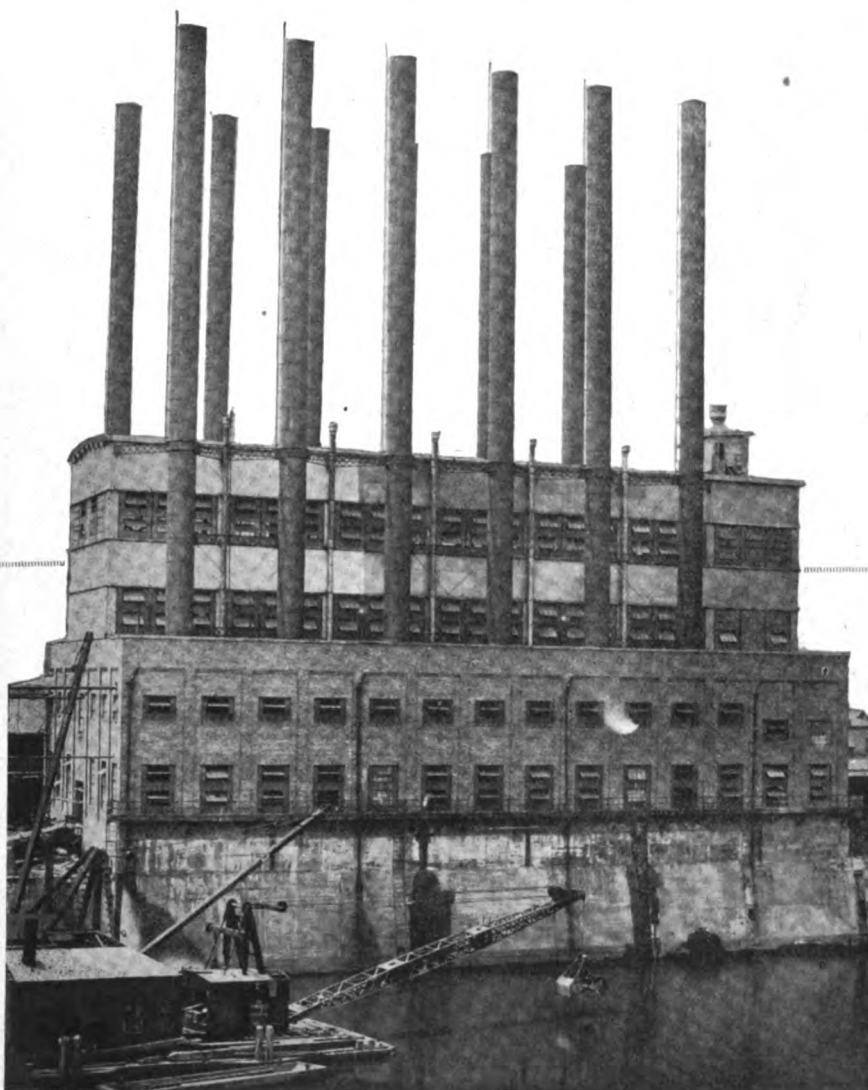
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Power Department

Power in the Steel Industry During 1921
By F. J. CROLIUS

Sloss-Sheffield Steel and Iron Company's Steam Generating
Stations
By M. M. ARGO and H. MAULSHAGEN

The Influence of Gas Cleaning on Plant Economy
By WALTER N. FLANAGAN



Power in the Steel Industry During 1921

During the Year Power Developments and Improvements Were Made and Future Improvements Were Authorized—Steam Power for Steel Plants Must Be Centralized into Single Large Stations.

By F. J. CROLIUS, Steam Engineer
Homestead Works, Carnegie Steel Company, Munhall, Pa.

THE year 1921 will long be remembered in the steel industry as one of acute contraction, sharp reduction in output, high comparative production costs and forced economies. Wastes of labor, materials, time and fuels stood out in stark contrast when charged against curtailed output. Power, which has always been relegated to the background, an undesirable necessity, a mere means to an end, was brought vividly into the foreground, as a function of extreme importance, worthy of constructive thought, a definite source of profitable recovery.

Looking back upon 1921, our impression is one of a long delayed, much desired "breathing spell when, after a mad race against time and production, we are given a

These widely distributed points of generation lent themselves to the super-power idea, but as a *heat-balance* the unrecovered exhaust presented a problem difficult of immediate solution.

Tieing together distributed sources of steam generation through long steam lines, while utilizing the benefits of super-power in averaging out the load, imposed the constant penalty of high condensation losses, and subjected the total system to the *minimum* pressures on that system.

The advent of the motor drive pointed the way to a solution.

The forces of concentration then became operative in the steel industry, and the influences which have made central station practice an accepted standard bore fruit. It became clearly recognized that the same kind of steam must be produced in steel mills as in central stations.

Where before steam making was a mechanical art, today steam power production is approaching an exact science, the era of the heat-balance has arrived.

When the full force of this concentration of power has been developed and applied a revolution in steel and iron will have been effected.

At this point it may be relevant to visualize a typical heat-balance of the most modern power-plant—the Colfax plant of the Duquesne Light Company. (Fig. 1.)

Analysis of this will indicate the values of recovered wastes—for therein lies the secret of heat-balance.

Applied to the steel and iron industry, this form of comparison brings forth a number of significant facts, certain recoverable wastes are enormous:

1. Wastes from coke produced in other than by-product ovens.
2. Wastes from steam produced in small, inefficient boiler units.
3. Wastes from steam utilized in small, inefficient engine units, and high pressure steam used in heating.
4. Wastes from steam driven equipment—replaceable by motors.
5. Wastes of water by leaks and misuse, necessitating excess pumpage, and the pumping of water by wasteful steam units.
6. Wastes of valuable heat-units in metallurgical processes.
7. Wastes of exhaust steam and heat from condensers.

Space does not permit detailed discussion of these several known evils, nor is it even necessary to point them out to engineers. Constant reiteration may serve to draw attention to them. Few seem to realize their magnitude, however. Fig. 2 is an attempt to present a

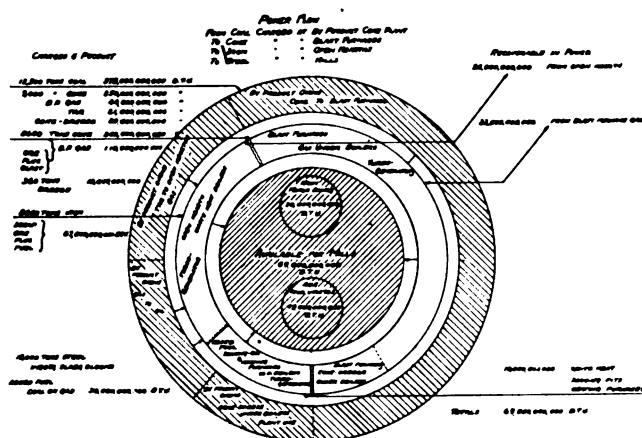


Fig. 1—Heat balance (Colfax).

chance to breathe and think and recover equilibrium, a chance to strengthen our fabric for the continuance of the competition.

And so, through the mists of depression, the sun shines forth through a number of defined tendencies, and though production was at times and places nearly stagnant, though facilities for production remained constant, power developments and improvements were "carried on" and further developments authorized.

A glance at the general power field will indicate the reasons for these influences.

Two major forces have been at work, the forces of distribution and the forces of concentration. The steel plant has been developed mainly under the forces of distribution.

Steam driven power units of comparatively small sizes could be operated advantageously in scattered units.

Blast furnace gases were utilized locally, waste heat recoveries were widely scattered small individual sources. Coke recoveries were deemed unimportant.

picture of recoverable wastes in the sequence of iron and steel processes. As a basis, a given amount of coal is charged at by-product ovens; the recovered coke is charged to produce its normal iron equivalent.

This iron, with a normal mix of scrap, ore, fluxes, etc., is charged in the open hearth to produce its average tonnage of steel ingots. The fuel fired is by-product tar and gas. These ingots are charged into soaking pits and reheating furnaces, and rolled in the mills to average practice of plates, shapes and blooms, the fuel used for heating is producer gas or pulverized coal, which must be added.

The power to operate is generated in boilers at various points, at coke ovens, fired with coke breeze; at blast furnaces fired with blast furnace gas and coke breeze; at open hearth, fired with waste-heat gases; and at heating furnaces, fired with waste-heat; this boiler steam through turbo-generators at various points—all mill units driven by motors.

Nothing empirical is suggested—all values are definitely known, all factors used are standard practice, but of course best practices have been selected at every point.

What this means when magnified to totals for the furnace coke industry can be expressed in a few paragraphs:

About 30,000,000 tons of iron is a fair annual average production. This means that some 50,000,000 tons of coal must be coked. About one-half this total is still produced in old-fashioned bee-hive ovens, from which nothing else is recovered but the coke; the available ammonia, the tar, the gases, which analyze into benzol, toluol, etc., are allowed to waste, to do no more than pollute the surrounding territory.

Within recent years we have been made to realize that we must recover these most valuable contents of the coal, or remain dependent for dye-stuffs, fertilizers, etc., upon some other nation whose necessities demand their recovery, and which nation has benefited at our expense thereby.

Just how busy *wasting* our "busy little beehive ovens" have been during their recent past is shown by the monument they have erected over their dead and worked-out mines; in the operation of drawing and screening the coke, a small percentage is broken off into fine pieces; this broken stuff is called braize, or coke-dust. It lies everywhere throughout the region where it has been allowed to accumulate until now the piles are estimated to contain millions of tons. The Btu. value of such coke dust approximates that of anthracite coal, and an enormous tonnage is available without great expense.

These piles form the *visible* loss, which only serve to emphasize the *invisible* loss of gases which for each ton of braize must be multiplied by 15. Fortunately, however, this condition is fully recognized by corporations prepared to remedy them.

The end of the beehive oven is in the not far distant future.

Power investigations have naturally fallen into two converging lines—generation and application, and while the lines of investigation have of course been carried on independently, the consequent result has been superimposed.

Of first importance in generation stands COMBUSTION. When we realize the comparative volumes of raw material which enter into the complete daily problem of the large iron and steel unit, the importance of *combustion* is seen.

Take, for example, a modern by-product coke plant—the blast furnaces it will serve, the open hearth furnaces the product of *these* furnaces will supply, and the mills required to break down and finish that steel.

The totals are enormous, and as each division presents its own unique problem, it has been so studied and investigated.

The many fuels used in a modern steel structure present a wide variety of characteristics—each interesting and important—but as coal is the one big item which shows up as direct purchase, which involves the most mechanical complications due to its mining, transporta-

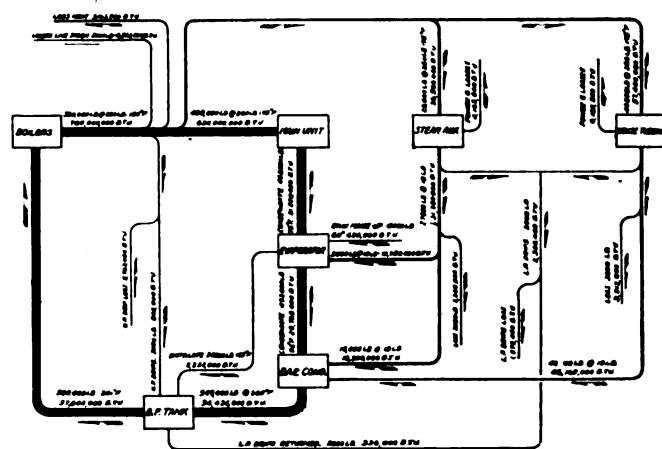


Fig. 2—Power flow graph.

tion, rehandling and preparation, *coal* has been subjected to closest scrutiny.

The logical way to burn coal has been found to be in pulverized fuel.

If 1921 has shown any clearly defined tendency, that tendency in COMBUSTION has centered upon *pulverized* fuel firing.

In a questionnaire by an engineering society as to topics of interest for discussion, pulverized coal was found to be the greatest in demand.

This widespread interest in the subject has been reflected in a large number of scattered installations—not great in total development, but each a nucleus around which interest centers, and expansion will take place as soon as the art is more firmly foundationed.

In particular, pulverized firing under boilers has expanded with the installation of many very successful plants, from a number of which accurate data is now available.

No detailed discussion is here necessary, as great publicity has attended a number of these plants. Much controversy is natural around a subject of such importance in which powerful forces are at work, but the elements of preference toward pulverized firing are so evident that it remains only to reconcile costs both of installation and of operation with known costs of other methods.

It is unlikely that the engineering profession will fail in the development of such an ideal.

Stokers have reached their peak—the reversion to the chain grate type, merely modified and expanded to meet forced draft, over-rating conditions, proves this. But the limitations of available grate surface are a vital consideration, and the necessity of a continuous sup-

ply of constant variety coal, classified as to size, is always present.

A paragraph from the annual report of the Prime Movers Committee of the National Electric Light Association is significant:

"While the application of the chain grate and under-feed type of stoker to high rates of combustion has seemingly been successfully accomplished, there are many indications that the art of burning coal economically is still in the process of development and that we cannot foretell at this time what methods may be used in the future. This must be particularly emphasized in view of recent installations and experiments which have been made for the purpose of utilizing pulverized fuels and by-product gases. New plants should be designed with this in mind, and special care exercised as to provision for modification and changes in such installations for future development."

Oil and tar firing present nothing new, while the rising price and future scarcity of these fuels make their use but temporary on land.

Blast furnace gas-firing has been well standardized with types of boiler equipment and burners well developed. The controversy between "dirty gas" and "wet-washed gas" seems pretty fairly settled in favor of "dirty gas"—a number of conversion back to dirty gas having been made, with no installation of importance made on "wet-washed gas." Dry cleaning of blast-furnace gas for boiler firing has been well developed in the

largest unit installed this year, and with excellent results.

Waste heat applications have made progress, not only on open hearth furnaces and heating furnaces, but also on duplex processes and even on gas engine wastes,

It is safe to declare that no large open hearth furnace plants will be built in the future without steam generating units included.

Nothing of importance occurred during the year 1921 in the gas-engine field. Bethlehem put into service a large gas engine unit, but no reports are yet available covering its performance.

Dr. Charles P. Steinmetz, a master mind in power development, summarizes, before the New York Electrical Society, the total situation so completely that repetition verbatim cannot be superfluous.

"The steam engine has been driven from factories and plants by the electric motor and the generator, and it will disappear from the railways of this country as soon as the railroads can finance electrification. The nation will eventually be covered with a network of transmission systems and dotted with hydraulic plants and power stations.

"In transportation the horse, the mule and the cable-car have become historical curiosities and the electric car reigns supreme. On our great trunk lines the anachronism of the steam locomotive still exists. But even the layman knows that only the unfortunate financial situation of our railroads makes the electrical propulsion impossible. It must be accomplished. The enormous consumption of coal by the railways, two-thirds of which could be avoided by electrification, must be stopped.

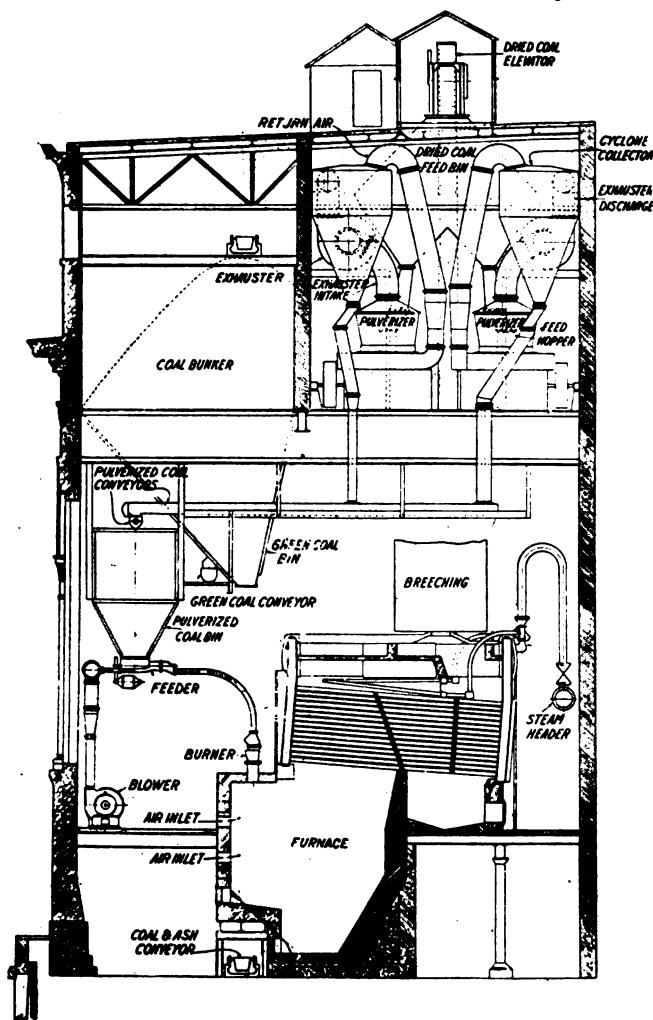


Fig. 3—Cross section through indirect firing pulverized plant.

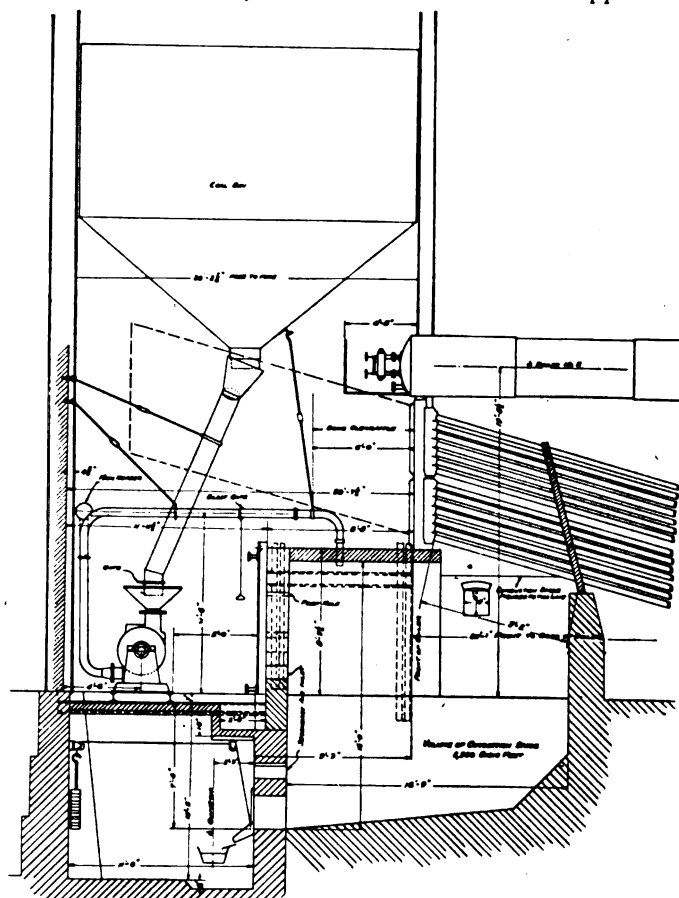


Fig. 4—Cross section through direct firing pulverized plant.

"When the first power plants were established at Niagara the question was asked whether electricity could not be sent to New York. A 100,000 hp. has been developed there, but no one asks the question any more. The reason is that the distance is so great that the electric power finds a market long before the limit of transmission has been reached. There is no economic excuse for transmission over long distances. Instead, a network of inter-connected generating and non-conducting units are springing up. It has already ignored the boundary of states, and the laws of different states are already in conflict, so that Federal supervision of power distribution will certainly be needed.

"Just as the railroads 75 years ago organized the transportation of materials, so the transmission of energy to turn our wheels and fetch and carry is being supplied by the electrical industry. Great factories which make electricity and supply it as other factories supply hats or stoves have come into being. Electrical energy is the only kind that can be easily, economically and simply conducted to the centers where it is needed, whether in small quantities for the vacuum cleaner and the house lights, or in huge masses for mills and factories. In long-distance transmission the huge voltage has crept up from 150 volts to 10, 30, 60 and finally 220,000 volts, and, experimentally, we have long gone beyond 1,000,000 volts to a voltage of 1,100,000. Just as in the past no one would have believed that possible, so in the future we may be laughed at for thinking we could not perhaps go further."

Several turbo-generator installations were completed this year, none exceptionally large, 20,000 kw. being the maximum. These at blast furnace plants where the controversy between gas engines and turbo-generator units was settled in favor of the steam conversion using surplus gas.

In the *application* of power, more progress is noted.

It is worthy of note that controlling metering, measuring and recording instruments are now considered an essential in all major power plant installations and should be an integral part of every generating unit.

A few years ago, and still in many places today, a steam gauge in the boiler room, another in the engine room and pump room were all that could be found to indicate that operations were in progress. The absence of recorders made comparisons or records impossible. To determine actual conditions, a test had to be engineered.

Regulation.

Where stoking equipment is being purchased, the question of regulation is usually disposed of by a clause in the stoker contract under the heading of "Automatic Regulation," and the only interest displayed in this subject is to find out whether the equipment is to be supplied by the purchaser or the contractor.

When the fact that the best designed and equipped plant in the country cannot be operated successfully in the absence of proper regulation is acknowledged by the engineering profession, the subject will be given the careful analysis it deserves.

Automatic regulation is too generally looked upon as a means merely to maintain a relatively constant steam pressure.

If this was the only requirement, the subject could be quickly disposed of since it is an extremely simple matter to connect up a piece of apparatus that will operate

on a given change of pressure to either open or close a damper or slow down or speed up the fan.

It is an altogether different problem, however, to properly co-relate the fuel feed, air supply and stack draft so as to meet the varying demand for steam and maintain maximum efficiency throughout the range of operation.

The Una-flow engine has reached a stage in its application where it is now receiving the consideration its outstanding advantages warrant.

Its great reduction in cylinder condensation, its low average water-rate over a wide range of load conditions, its adaptability to high super-heats, to condensing operation, owing to amply proportioned exhaust chamber and large exhaust port-area, make it desirable for rolling mill drives, where a widely variable load condition is found.

Several interesting installation of comparatively small size have been made, and considerations of the direct drive of a large blooming mill by Unaflow is now in the development stage. The builders who have specialized in this type engine have no hesitation in offering single-cylinder units as large as 6,000 hp. and twin-cylinder up to 12,000 hp.

Turbo-generators have been installed in many representative plants, none exceptionally large, as present steel mill loads do not warrant larger sizes at present and none of radical design. Among these may be mentioned:

Turbo-blowers have become standard practice at blast furnaces, competing on even ground with gas engine blowers, without the necessity of costly gas washers, and with higher factor of reliability.

Turbine driven pumps seem to have been preferred to reciprocating units, principally on the score of economy in space and most of the installed power units have incorporated turbine pumps to even out the heat balance.

Turbine drive for direct-firing pulverizing units have proven more satisfactory than motors, not only due to reliability and flexibility—but also due to simplicity of controls over a range of capacities.

To close a stack damper with an intense fire on the stoker simply because the steam pressure had gone up a pound or two, was decidedly bad practice and extremely hard on chain grate links, for instance.

If the stack damper and stoker speed had been regulated not from one extreme to another, but to maintain a definite relation between coal supply, air supply and steam demand, there would have been no room for complaint on the part of the stoker man and the plant operator would not have been compelled to sacrifice 10 per cent to 20 per cent efficiency in order to protect his stoking equipment from damage.

Some of the biggest force draft traveling grate installations that have been made during recent years were installed without regard to regulation and maximum results were not secured until after this subject had received the proper attention and the necessary apparatus had been installed.

Powdered coal is kicking up a lot of "dust" these days and at least one boiler in America has absorbed a lot of it efficiently. If you investigate the various installations throughout the country you will find that little or no thought had been given to proper automatic regulation. In fact, it would seem that if you powder coal the amount of air required to burn it takes care of itself.

The proper application of regulation to blast furnace stoves will help silence the howl in the boiler room for "more gas."

The proper system of regulated burners in the boiler house will result in a maintained efficiency, providing other things are in good condition in excess of 80 per cent.

Today the modern power plant is a *continuous test* record—a daily heat-balance.

Metering.

Not less important than regulation, we find metering coming to be recognized as essential in plant operation. Definite quantities enter into the total problem and without a quantitative comparison, no attempt at regulation can be made.

Flows of water, feed water, condenser water, condensate, cooling water, flows of steam, air, coal, gases are now and should be covered by meter.

Incident to meters, records of their operations must be kept, and today one of the interesting points of assembly in any power house is the instrument board, where at a glance the "book-keeping" of enormous daily quantities can be seen. Each engineer has his personal idea as to arrangement and selection of a wide range of recording possibilities—but in general, a combination of flows should be selected which will approximate test data.

A review of 12 months' practice would not be complete without a slight payment upon the mentalities that have influenced that practice. Many things are taken for granted, and most of all the proceedings of the engineering societies that seem to be accepted in the same gratuitous spirit in which such work is given. But it should not pass without comment.

No year has been more replete with engineering activities and no year has seen greater interest, and more definite applicable knowledge disseminated by the societies and the leading trade journals. The proceedings of the various societies and trade journal publications have focused general executive attention, the published reports present a mine of valuable data.

Power in its various manifestations has shared largely in the total scope of engineering activities, its characteristics have been analyzed, recorded and discussed, many conclusions have been reached and further investigational activities have been stimulated.

The individual names of the contributors and the board variety of subject-titles would form a volume in themselves. Suffice it to say that the activities of 1921 bid fair to outstrip 1920 even in greater ratio.

Every discussion of power, its production, distribution and application, should be introduced by a section on *safety*, and should not be complete unless *concluded* by emphasis upon *safety* and then *more safety*.

Because power in its production involves the very factors which constitute the most serious hazards—high temperatures, high pressure, high velocities, high rotative speeds, huge masses, noxious gases, explosive dusts and dirt, high elevations, etc. These hazards result naturally in burns, scalds, fractures, amputations, asphyxiation, loss of members, sight, falls and deaths.

Power in its distribution involves the same elements plus other equally hazardous, such as electrovention, explosions, etc., while power in its application includes all the foregoing, plus additional hazards incidental to the personal equation, such as grinding wheel failures, air

hammers, electric hand drills, etc., etc., too numerous to detail.

Wherever we look this high tension industrial civilization seems to point to a compounding of personal hazards.

In the face of all this it is gratifying to note that this apparently most dangerous feature of our individual organization is actually about the *lowest* in actual recorded accidents and fatalities; just because power is dangerous, it has been *recognized* as dangerous, and safeguards have anticipated the hazards.

Today *specific* codes of procedure surround the installation and operation of all power elements—it is accepted specification—to install non-return valves on all boilers, feed-water regulation, gauge-glass protectors, duplicate water lines; engine stops are as acceptable as governors, hoisting equipment is guarded, and automatically "safety-stopped;" all gears are guarded, electric switches are of the enclosed, locked type. Wherever pulverized coal is burned definite provision must be made to cover the hazards it presents, likewise blast-furnace gas.

The net result of this *recognition* of hazards has placed power in the preferred class in all safety statistics.

When you enter a power house, a safety-first sign confronts you; wherever you turn, a safety appliance interposes itself; when you leave your last impression is one of tremendous forces under marvelous control. Nowhere has safety shown greater results.

An annual review of any subject must be, at best, a mass of generalities, and in a survey of the breadth of power such is particularly the case.

But there is a point of contact wherein the subject may be made to touch the individual reader, especially if he be an operating man or an executive engineer.

An this takes the form of a New Year suggestion—*write your own annual power review*.

There is no better way to visualize *your* progress forward or backward.

Did your operation for the closing year reflect advancement?

Were your costs higher?

How much did your combustion improve as reflected in higher evaporations per pound of coal?

Did you reduce man-power by the substitution of automatic devices?

Are you familiar with progress elsewhere?

What experiments did you enter into, and were they successful as applied to your problem?

What fundamental principles did you discover or utilize?

What magazine articles interested you or influenced you?

What engineering society proceedings interested you?

These and a hundred questions may be made a matter of valuable record, both for yourself, your successors and your company.

It is quite remarkable how valuable written facts may become, especially as a sure means of comparison—without which small progress is made.

The essence of an entire operation may be summarized upon a single comparison sheet and your personal analysis of the results of the year will be well worth filing.

In conclusion, as a summation of the possibilities of heat-balances, waste recoveries, super-power, etc., should we look into the far distant future, we might see a picture something like this:

All coal now mined along the Monongahela and Allegheny basins, now loaded in cars and hauled upon congested railways already overtaxed to handle produced material, and raw material tonnages, with various transshipments, reloading and haulages—all this coal assembled at two central points, say Clairton and Colfax.

At these points it would be elevated by tremendous grab-buckets, capacity of 1,000 tons per hour (20 cars); there coked, and all by-products recovered, gas generated to maintain present dwindling natural gas supplies, the sulphates for fertilizers, the benzols for automobile power.

The coke braize, now wasted, would be pulverized, the ash precipitated out by a process similar to the Trent and mixed with tar already recovered.

In this condition we have an ideal colloidal fuel (all recovered as by-product), which can be pumped through pipe-lines to the various points of consumption.

Such fuel presents no problems of combustion, as it is ideal for high temperatures and high ratings.

The ash having been eliminated at the central preparation plants, we have no ash handling problem, no ash and dirt, with consequent wear and tear, cost of shipment now necessary upon cars, where coal is burned (?) as at present.

The installation cost of such a plant layout will be well within the recoverable values.

Sloss-Sheffield Steel and Iron Company's Steam Generating Stations

Descriptive Article of the Modern Steam Generating Plants of This Company Located at North Birmingham, Alabama—Mine Power Plant Also Discussed.

By M. M. ARGO and H. MAULSHAGEN*

A DESCRIPTION of the latest and perhaps one of the most efficient steam generating stations in the southern district in connection with the production of iron and steel is the boiler plant and generating

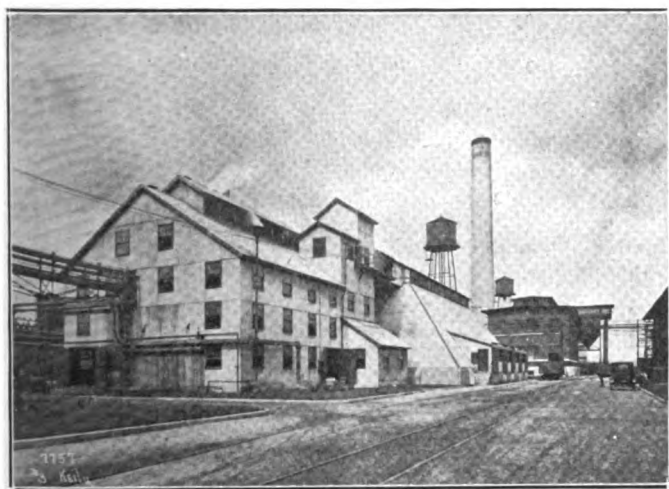


Fig. 1—View showing sulphate building of by-product plant. Boiler plant beyond railroad car. Concrete stack of boiler house plant can be seen.

their by-product coke oven plant, located in North Birmingham, Ala.

Fig. 1 is view of outside of boiler house, showing station of the Sloss-Sheffield Steel & Iron Company at

*Mr. Argo is power engineer and Mr. Maulshagen is assistant power engineer of the Sloss-Sheffield Steel & Iron Company, Birmingham, Ala.

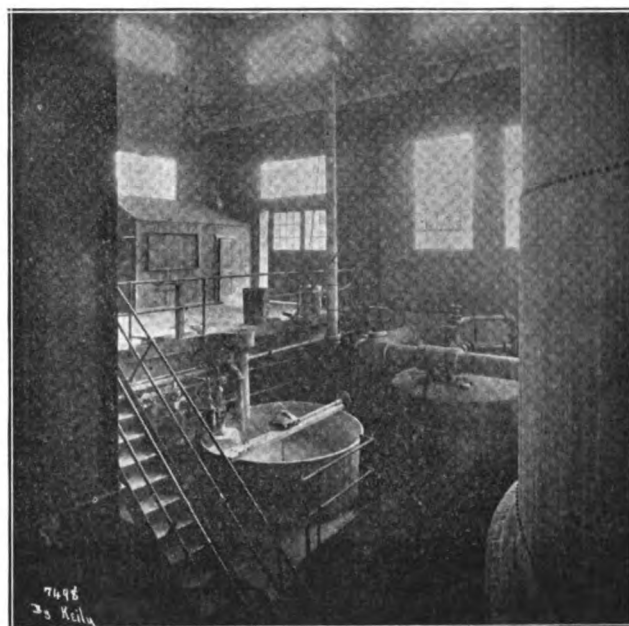


Fig. 3—View showing purification plant, mixing tank, filters and sedimentation tank.

location of ash hopper on right over tracks where ashes are discharged from bottom directly into railway cars.

The ashes are discharged into the hopper by the Peck Carrier System, manufactured by Jeffrey Manufacturing Company. The Peck Carrier System also elevates the coal, which is discharged into a hopper under railway tracks beneath the ash bin and fed into the buckets

by motor operated shakers. The trips above are set so as to discharge the coal, coke breeze or ash into their respective bins. This system is operated by a 30-hp. Westinghouse 440-volt 60-cycle induction motor and has a capacity of 150 tons per hour.

Fig. 2 gives a front view of the eight boilers.

These boilers were manufactured by the Babcock & Wilcox Manufacturing Company and have 6,032 square feet of heating surface each, and are rated at 603 hp., or a total of 3,618 hp. One hp. equals $34\frac{1}{2}$ lbs. H_2O evaporated from and at 212 deg. F. per hour. The three steam drums are 43 in. by 13 ft. 10 in., and mud drum 48 in. by 12 ft. $7\frac{5}{8}$ in. There are 462 $3\frac{1}{4}$ -in. diameter tubes. All boilers are equipped with Babcock & Wilcox patented superheaters, which have the following rating:

100 per cent.....	150 deg. S. H.
150 per cent.....	168 deg. S. H.
200 per cent.....	185 deg. S. H.

The boilers at present are operated at 200-lb. steam pressure 150 per cent rating and an average of 170 deg. S. H. is obtained. Each boiler is equipped with Diamond Power Specialty Company's soot blowers and all except the stoker fired boilers are equipped with Engineering Company's balance draft regulator. They have a combined space of 1,600 cu. ft. and four are equipped to burn gas only, two gas or coal, and two are stoker fired.

The gas and hand fired boilers have the Deitrick fire box of the Dutch oven type with non-water cooled arch. The stoker fired boilers have the Deitrick arch, fan-shaped arch and water cooled top.

The four gas fired boilers are equipped with eight Burkholz Terbeck gas burners which are designed to supply sufficient gas to operate the boilers at 200 per cent rating. The four top burners are controlled by 8-in. Mason regulator, which was redesigned at this plant for this special duty; four are set by hand for normal load and regular operated valves taking care of variations.

As seen by the photograph above it was necessary to supply additional secondary air to the burners, which was done by cutting out the brick around the top of the burners in the front of the fire box; the admission of this air is also controlled by the Mason regulator operating the gas supply to the burners. The gas as burned has heat content of 570 Btu.

Flue gas analysis on gas fired boiler is as follows:

130 per cent rating of boiler	CO ₂	8%
	O ₂	5%
	CO	0

Stack temperature 570 deg. F.

150 per cent rating	CO ₂	7.2%
	O ₂	4.7%
	CO	0

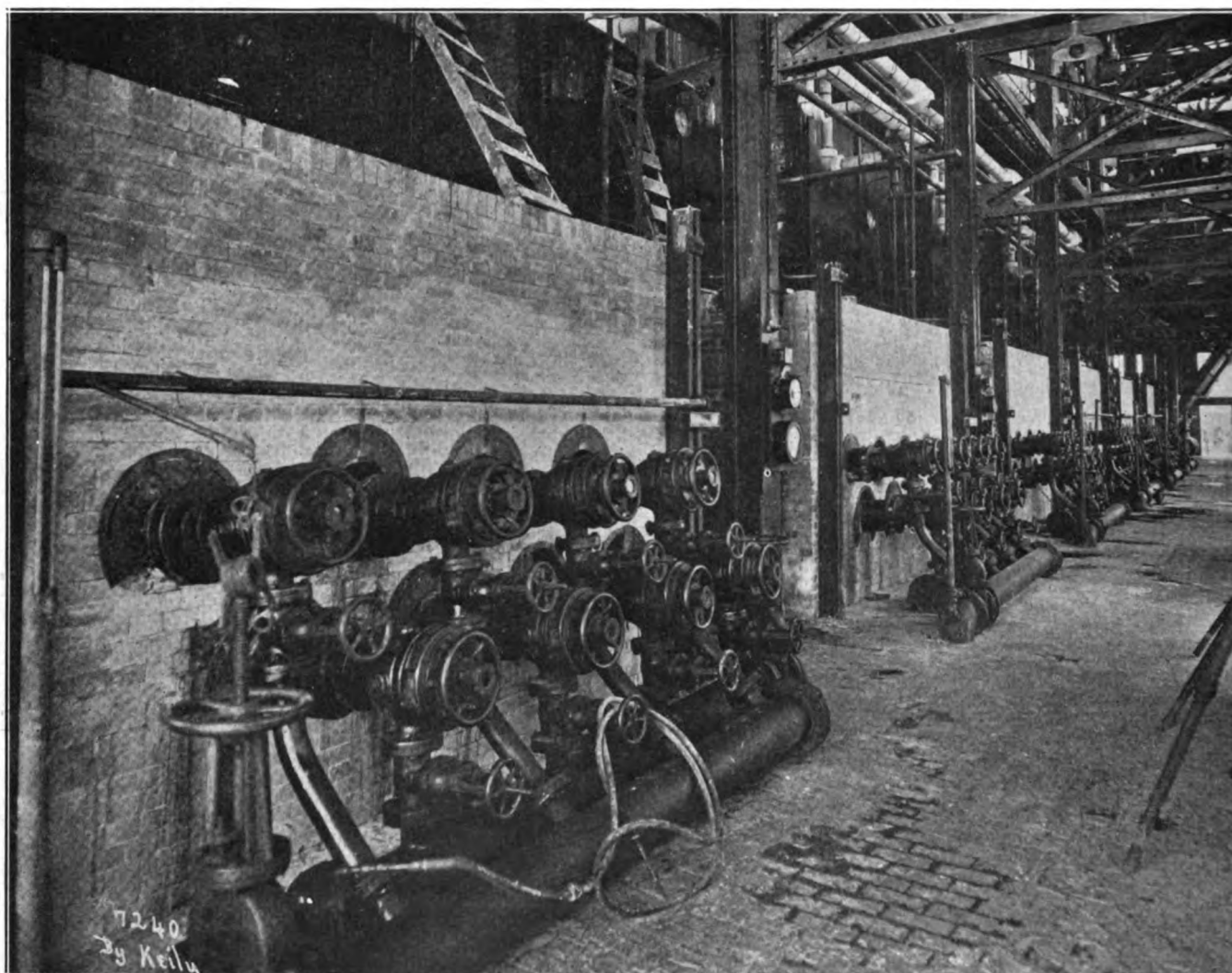


Fig. 3—Front view of the eight boilers.

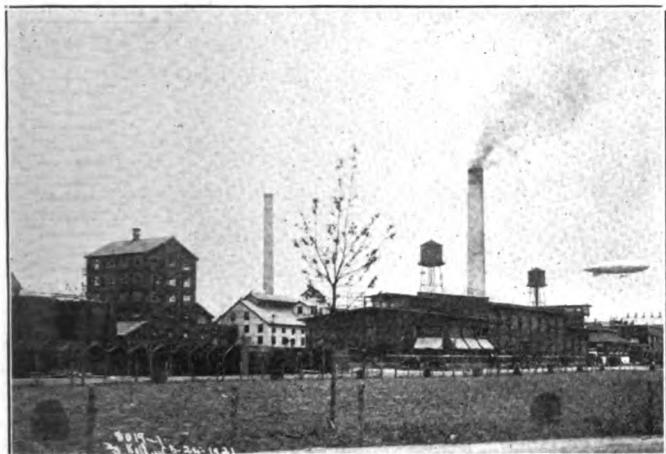


Fig. 4—View of the by-product plant showing boiler plant and power house at the right.

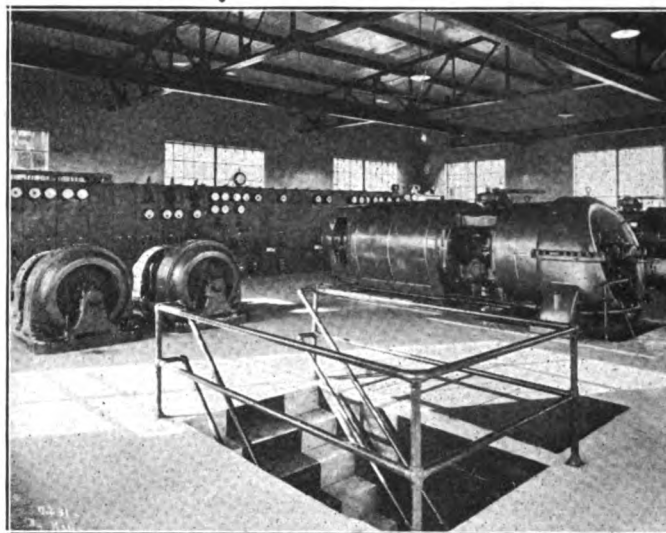


Fig. 5—Interior view of by-product power house, showing two 2,000-kw. turbo-generators and two 150-kw. motor generators.

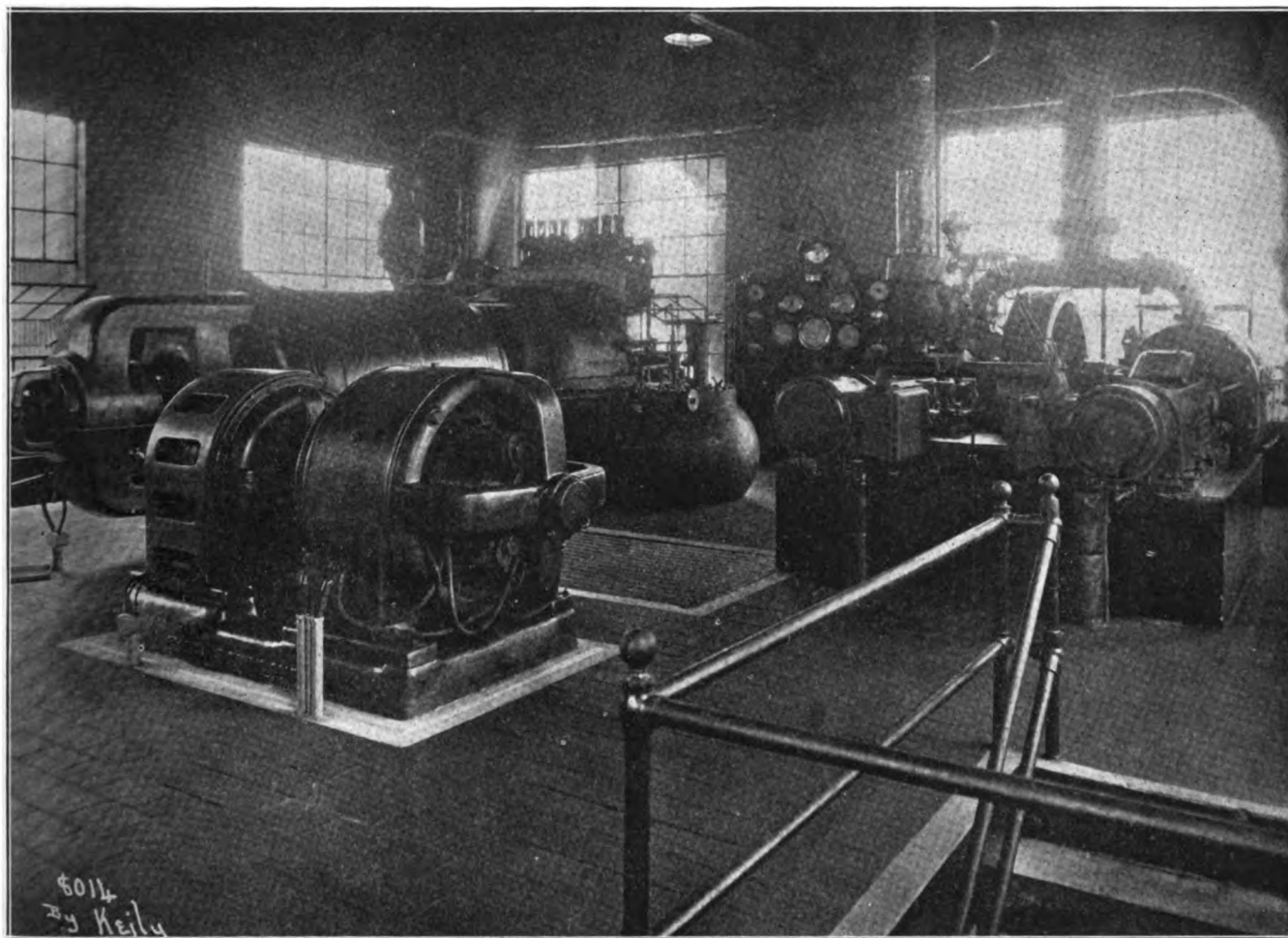


Fig. 6—Interior view of furnace power house showing gage board, 2,000-kw. mixed pressure turbo-generator 3 phase 60 cycle 6,600 volts. Ingersoll-Rand vacuum pump. 100-kw. motor generator 2,200 volts, 3 phase, 60 cycle 250 volts d.c.

Stack temperature 580 deg. F.

170 per cent rating

CO ₂	8%
O ₂	5.4%
CO	.9%

Stack temperature 600 deg. F.

The boilers are equipped with five gas burners each

and also have stationary grates for hand firing, which permit hand firing when the gas supply is low due to increased demand by City of Birmingham. The City of Birmingham obtains its gas supply from the by-product plant, where the boiler plant and central power plant of the company are located. The boiler plant only utilizes

the surplus gas which is not needed by the city.

The stoker fired boilers are equipped with Combustion Engineering Company's chain grate stokers of the Coxé type, capable of burning coke breeze or coal, coke breeze being burned at the present time. Each grate is operated by a 25-hp. 250-volt d.c. variable speed motor, through suitable reduction gears, giving a grate speed of from 10 to 20 feet per hour. Forced draft is

ignition arch was changed from a water cooled arch at 45 deg. to a fan shaped ignition arch of the Deitrick type. With a few other minor changes, the stokers can now be driven at 225 per cent rating with ease.

Feed Water System.

The feed water system consists of three 500-gallon centrifugal pumps operating at 275-lb. pressure each. Two are turbine driven and one is motor driven. Feed

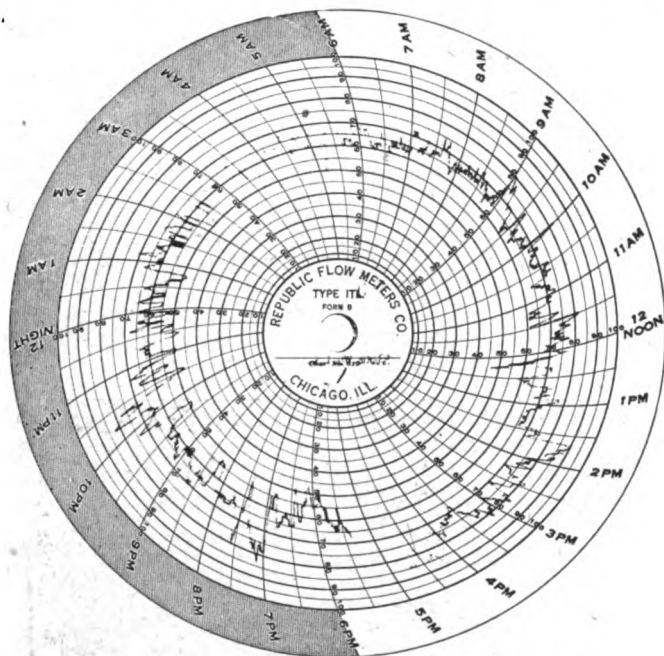


Chart 1—Showing varying output of gas fired boilers controlled by regulator.

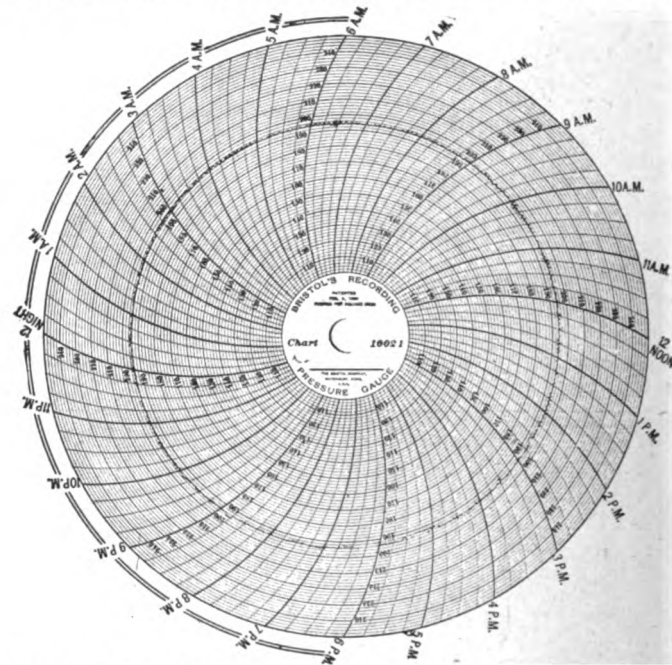


Chart 2—Chart from recording steam pressure gage showing small variation in pressure controlled by the Mason regulator.

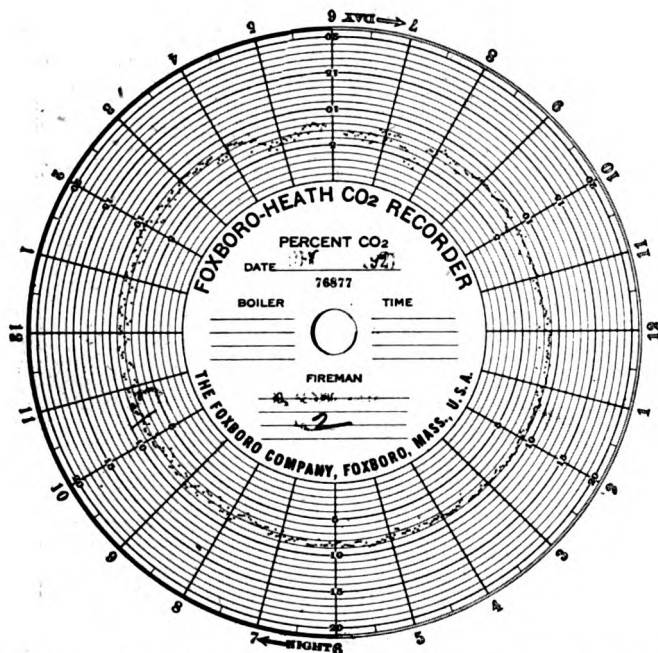


Chart 3—CO₂ gas fired boiler showing slight variation due to gas regulator action.

supplied by a Siroco blower, driven by a 100-hp. Waite turbine. A similar blower driven by a 100 motor is used as a spare.

Considerable difficulty was experienced at first in burning breeze with the Coxé stokers, and a careful study was made to determine the cause of the trouble. The

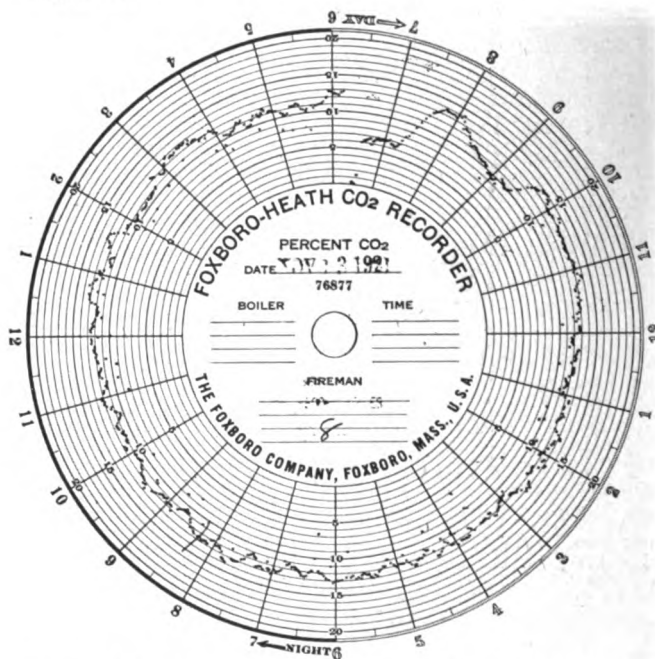


Chart 4—CO₂ chart on chain grate stoker boiler burning 22 Lr coke breeze.

water pressure is controlled by a Copes automatic feed valve and diaphragm governor handling a differential between the steam pressure and the water pressure of 30 to 40 lbs. The boiler feed water is treated by the Sorge-Cochran hot process water softener, consisting of chemical tank, sedimentation tank, and three sandfilters.

Chemicals used are lime and soda ash.

The fundamental principle of this treatment is that lime and soda ash in the correct proportion mixed with the raw feed water in the heater and in the sedimentation chamber at a temperature above 205 deg. will completely react within 10 minutes and precipitate all scale forming salts in the sedimentation chamber, which are removed by blowing off the sludge at the bottom of the sedimentation tank. The suspended matter will be removed as the water passes through the filters, leaving the sedimentation tank on the way to the boiler feed pump. The soluble salts then pass over to the boiler and constitute the total solids, or the concentration of the water in the boiler. The concentration is lowered or total solids removed by blowing the boilers at regular intervals for a specified time, which is determined by the test of the water taken from each boiler.

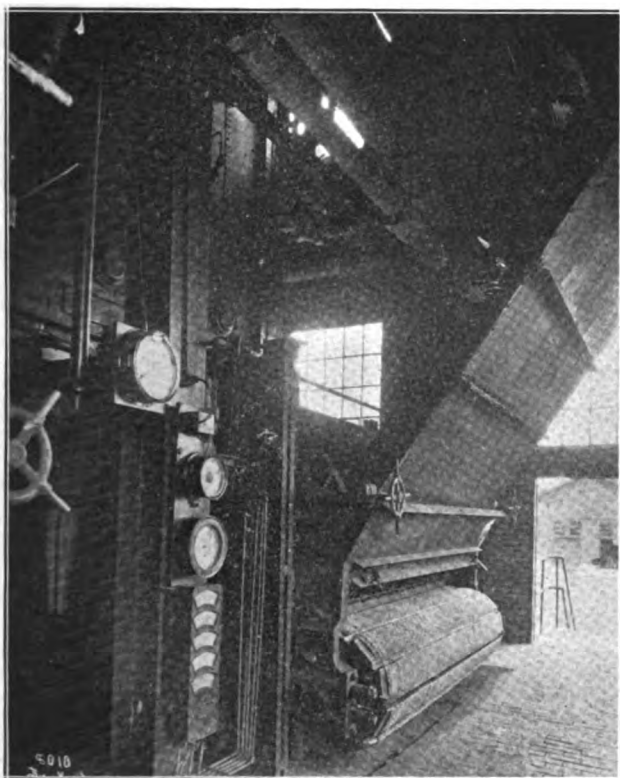


Fig. 7—Combustion Engineering Company chain grate stoker. Also shows record thermometer, Bristol recorders, Republic instruments and steam flow charts and precision instruments.

The air in the water is removed in the open-type heater on the top of the sedimentation tank. Live and exhaust steam is used to heat the feed water and the raw feed water as applied has a hardness of 14 grains per gallon. By treating this with six pounds of soda ash and 9.5 pounds of lime per each 1,000 gallons of water, which is the correct treatment at present, to total hardness of soap solution, test is reduced to $2\frac{1}{2}$ grains per gallon, with the total solids averaging 7 grains per gallon. The boilers begin to show signs of priming at 250 grains. Concentration, therefore, is kept below 150 grains per gallon by blowing down the boilers at intervals of 1.5 hours for 80 seconds per boiler. The length of the interval and time of blowing is governed entirely by the load on the boiler, blowing longer and more frequently as the load increases. The alkalinity of the boiler is kept above 20 grains per gallon and below 30 grains per gallon. If the water becomes neutral of

acid, scale forms, so that 20 grains per gallon is used as a safe margin to work upon. If it goes above 30 grains per gallon, it deposits a lime coating on the interior of the boiler.

The test on the treated water is made with Ph and Mo as indicators and $\text{Na}_2\text{O H}_2\text{SO}_4$ as reagent. The Ph indicates all hydroxide and one-half carbonate, and the Mo the other half of the carbonates. The theoretically correct treatment is 1. Ph and 2.4 Mo. A test is made of the treated water every two hours, and of the boiler water for alkalinity and concentration once each day. All tests are recorded and filed. The concentration is found by determining the grains of sodium chloride per gallon with AgNO_3 as reagent, and multiplying the ratio of the NaCl to the total solids which is a definite factor. The capacity of the water softener is 5,000 lbs. per hour.

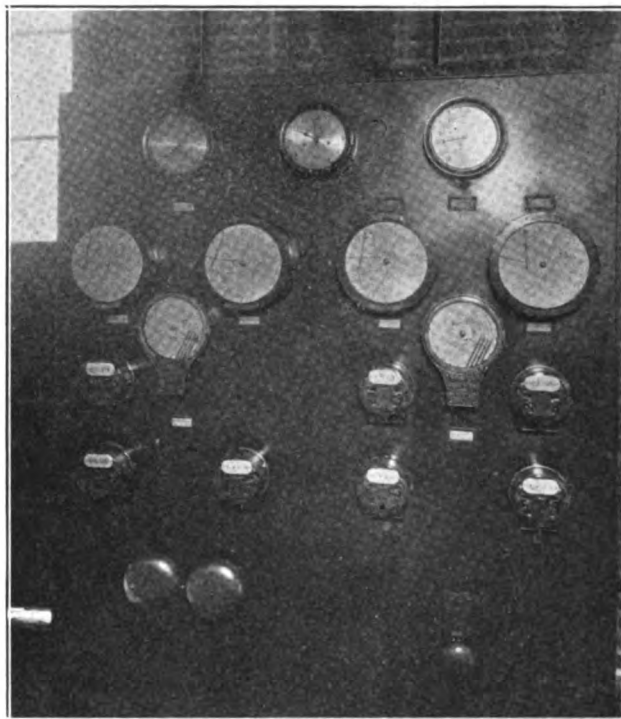


Fig. 8—Gage board in boiler house showing, top row, left and right: Steam pressure and boiler feed water pressure gage. Second row: Recording steam pressure gage, feed water pressure, steam temperature in header, gas pressure. Third row: Boiler blow off recorders. Fourth and fifth rows: Integrating steam flow meters, one for each boiler.

One very noticeable feature of this plant is the accuracy of the records. Every pound of feed water or material is either weighed or measured that enters the plant. All steam leaving the plant is measured. Accurate records are kept from day to day as to the operating cost. The efficiency of the plant is very high, considering the slow operation, and the fact that the boilers are carrying only a slight overload; the efficiency is held approximately at 70 to 75 per cent. If conditions were such that the steam was needed, the daily efficiency would possibly be much higher. The Deitrick fantail ignition arches have proven very satisfactory for burning coke breeze from the ovens which has been coked 35 hours. The majority of the plants have been unable to burn the breeze without mixing coal with it, where it has been coked over 22 hours.

By-Product Power House.

Included in the equipment of the power house are

two 2,000-kw. 6,600-volt, 3-phase, 60-cycle, 80 per cent power factors generators driven by two 2,000-kw. condensing turbines, operating at 3,600 rpm. and 200-lb. steam pressure. The turbines and generators are direct connected. Mounted on the same shaft as the generators are 125-volt exciters. The two turbines exhaust into the Elliott-Erhart jet condenser. The air from the

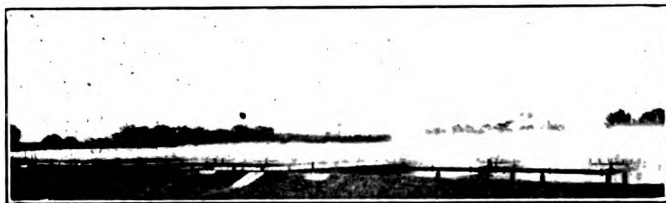


Fig. 9—Spray ponds. Two at left are power house used with jet condensers, others are used in cooling mill water recirculated through mill system after cooling. Sprays reduce temperature 3-4° below atmosphere.

condensers is extracted by ejectors. The water is pumped from the condenser by an Elliott-Erhart centrifugal pump, driven by a Terry steam turbine. The switchboard was manufactured by the Westinghouse Electric & Manufacturing Company and consists of 25 panels, controlling 6,600-volt circuits to the generators, mines, by-product plant, etc. The switchboard has recording

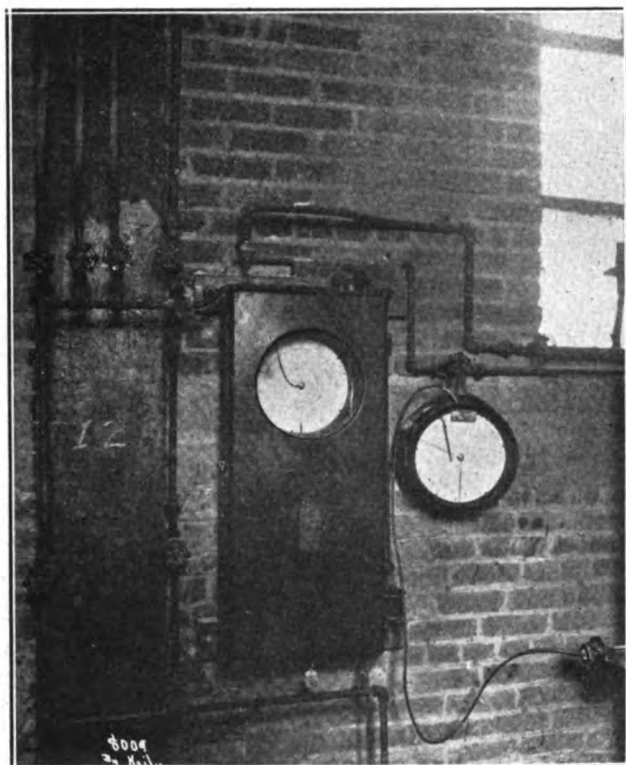


Fig. 10—Flue gas stack thermometer CO₂ recorder.

and integrating meters, maximum demand meters for determining the load on the different circuits besides the regular meter equipment usually found at the switchboard.

North Birmingham Plant.

An additional power plant, located at the North Birmingham furnace of the Sloss-Sheffield Steel & Iron Company, and the idea in locating a unit here was to utilize low pressure steam exhausted from the furnace

by blowing engines. This plant, as well as the one located at the by-product plant, was designed by Martin J. Lide, consulting engineer and mechanical engineer of the company, and the construction was carried on under his guidance by Mr. T. B. Dryer, construction engineer.

The furnace plant at the present time consists of one 2,000-kw., 3-phase, 60-cycle, 6,600-volt G. E. turbo-alternator. This turbine is a mixed pressure machine, taking the exhaust steam when the blowing engines are operating and automatically changing to high pressure steam at 125-lb. gauge pressure when the exhaust steam is not available. This machine is very rugged and capable of handling a heavy overload without injury. One of the interesting parts of the plant is the condenser, which was designed by Martin J. Lide, and is the largest condenser of the barometric type in the Birmingham district, requiring 8,000 gallons injection water a minute. High vacuum is maintained, giving a high over all efficiency of the plant. A water rate of 32 pounds is averaged, which is considered very good for a mixed pressure machine. The other equipment in the plant consists of an Ingersoll-Rand vacuum pump, two Midwest circulating pumps, one motor and one turbine driven of 7,500 gallons capacity each against a 42-ft. head. The switchboard and motors were furnished by the Westinghouse Electric & Manufacturing Company. The steam flow motors were furnished by the Republic Flow Meters Company. The plant receives an average of 1,250-kw. from low pressure steam with one blast furnace operating.

Distribution.

Between the two plants there is a double 6,600-volt tie in line, capable of delivering 3,000 kw. at either end in case either plant is shut down. Feeders leave each plant to the furnaces, by-product plant, coal mines and rock quarry. The voltage is stepped up to 44,000 and is transmitted to the several coal mines 18 miles distant. Current for the by-product plant is stepped down to 440 volts. The transmission line to the ore mines, near Bessemer, 15 miles distant, has not yet been completed.

Mine Power Plant.

This plant is being built as a standby plant in case of interruption to the service or to the lines due to transmission line trouble. The plant consists of two 750-kw., 3-phase, 60-cycle, 2,300-volt turbo-generators made by the Allis-Chalmers Manufacturing Company. The turbines have been thoroughly repaired and are capable of handling a large overload. Suitable transformers tie this plant into the power system. The boiler plant consists of four Sterling boilers rated at 361-hp. each, 150-lb. gauge pressure, and are equipped with Diamond soot blowers.

NEW POWER MAP OF PENNSYLVANIA.

A map of Pennsylvania showing the location of the power stations and electric transmission lines used by public utility companies has just been published by the United States Geological Survey, Department of the Interior.

This map is the second of a series now being published, that of New York having been recently issued. Two other maps are nearing completion, one covering New Hampshire and Vermont and the other covering Massachusetts, Connecticut and Rhode Island, and maps of Maine, New Jersey, Maryland and Delaware are also in preparation. These maps were prepared in collaboration with the power companies.

The Influence of Gas Cleaning on Plant Economy

Comparison of Dry Cleaning vs. Wet Washing of Raw Gas—Dry Cleaning Will Prove Advantageous in Every Case of Combustion of Blast Furnace Gas, With the Exception of Its Use in Engines.

By WALTER N. FLANAGAN
Steam Engineer, Ohio Works, Carnegie Steel Company

BLAST furnace gas is one of the nicest fuels to handle if properly taken care of and one of the meanest fuels if the equipment is not carefully considered. It is only in very recent years that the above remark could be made. Formerly the gas was considered difficult to handle, difficult to burn efficiently and caused endless trouble with dust. All of these troubles have been greatly reduced and in fact practically eliminated in some installations. On account of the low heating value and large volumes produced, large pipes and valves are required. Since the gas is poisonous the valves must be tight and only goggle valves are now considered. To eliminate the necessity of a large crew of men working for hours up in the air in a gas laden atmosphere to open and close a valve, a type of goggle valve has been developed and put into successful operation which can be operated from the ground in two minutes by two men. Properly designed burners eliminate combustion troubles. Dust troubles can be eliminated by cleaning the gas.

However in most installations equipment is used which only partly cleans the gas and delivers it saturated with moisture that precipitates out in the lines carrying dust along which eventually causes clogging. For stove and boiler operation the absolute cleaning of blast furnace gas would be too expensive. One quarter of a grain per cubic foot is now the accepted value of cleanliness for wet washed gas to insure freedom from dust troubles in stoves and boilers. The latest developments have shown that up to one-half grain per cubic foot is just as satisfactory if hot, dry cleaned gas is used.

The heat contained in blast furnace gas consists of the calorific value and the sensible heat or heat due to temperature. When the gas is cleaned in contact with water the temperature is reduced, usually to the temperature of the water, thus the sensible heat is lost in an effort to eliminate dust troubles.

The analysis of many samples of blast furnace gas showed an average of:

CO ₂	13.50%
O ₂	.11%
CH ₄	.22%
H ₂	3.72%
CO	25.20%
N ₂	57.25%

This gives a lower calorific value of about 93.4 Btu per cu. ft. of dry gas at standard conditions.

Fig. 1 shows the heat loss per cu. ft. of gas by

washing, for various initial gas temperatures. The washed gas is assumed to be cooled to 62 deg. F. which is the average final temperature in most plants where a satisfactory cleaning is obtained, and to have a moisture content of 6.3 gr. per cubic foot which is slightly less than saturation at that temperature. The raw gas is assumed to contain 35 grains of moisture per cu. ft. which represents average conditions.

Fig. 2 shows the monetary value of the sensible heat loss, based upon \$4.00 coal while Fig. 3 shows the relation of the net sensible heat value to the total value of blast furnace gas. In all of the above figures the heat saved is the difference between the heat required to raise washed gas and that required to raise hot gas to the same stack temperature.

The loss due to cooling blast furnace gas may be calculated for any condition as follows. Since the

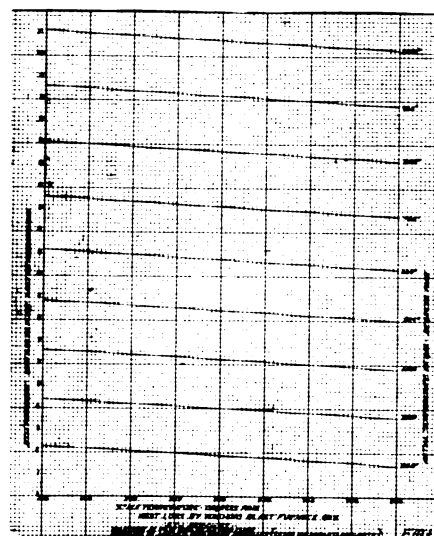


Fig. 1.

specific heat of gases at high temperatures is not constant the curves of Fig. 5 are included to furnish a means, accurate enough for all practical purposes, of calculating the sensible heat of blast furnace gas and the heat loss due to cooling the gas.

The density of water vapor is approximately .04767 lb. per cu. ft. and the volume of water vapor per cu. ft. of gas can be readily calculated if the moisture content in grains per cu. ft. is known.

From the analysis and moisture content of the gas

and the curves of figure 5 the tabulation may be made as follows:

Gas analysis.....Given below.
 Moisture in raw gas.....35 grains per cu. ft.
 Temperature of raw gas.....400 deg. F.
 Moisture in washed gas.....6.3 grains per cu. ft.
 Temperature of washed gas..62 deg. F.
 Stack temperature.....600 deg. F.

Vol. of moisture in raw gas—

$$\frac{35}{7000} \div .04767 = .1049 \text{ cu. ft.}$$

Vol. of moisture in washed gas—

$$\frac{6.3}{7000} \div .04767 = .0189 \text{ cu. ft.}$$

Constituent.	Fraction per cu. ft. of dry Fee. Gas.	Heat cu. ft. from 62-400° Btu.	Heat, cu. ft. from 62-600° Btu.	Heat, cu. ft. from 400° to 600° Btu.	Total Heat from 400-600° Hot Gas Btu.	Total Heat from Washed Gas Btu.
CO ₂	.1350	8.5	14.0	5.5	.743	1.890
O ₂	.0011	6.2	10.0	3.8	.004	.0011
CH ₄	.0022	8.6	14.3	5.7	.013	.032
H ₂	.0372	6.2	10.0	3.8	.141	.372
CO	.2520	6.2	10.0	3.8	.957	2.520
N ₂	.5725	6.2	10.0	3.8	2.175	5.725
H ₂ O (Hot Gas)	.1049	7.3	12.1	4.8	.503	...
H ₂ O (Washed Gas)	.0189	..	12.1	..	...	.229
Totals					4.536	10.779
Less Heat required for hot gas.....						4.536
Available sensible heat, or heat loss by washing, per cu. ft.....						6.243

The value of blast furnace gas or of the sensible heat content may be calculated as follows on heat value basis:

$$\begin{aligned} &\text{Dollars per furnace per year=} \\ &\frac{(\text{Ave. cu.ft. per min.}) \times (\text{Btu per cu.ft.}) \times 1440 \times 365}{2240 \times (\text{Btu per pound of coal})} \\ &\quad \times (\text{Dollars per ton of coal}) \end{aligned}$$

From a 500-ton furnace there is at least a net flow of 50,000 cu. ft. of gas per minute. This is the basis of the curves of Figures 1 to 4.

In any plant where coal has to be burned continuously to supply power the actual value of the gas is higher than shown on a heat value basis since usually less equipment and labor is required than for coal to maintain a given efficiency.

The value of the sensible heat of blast furnace gas is shown in Figure 2. The average furnace in the United States has an average top temperature of about 400 deg. F. This means an annual value of at least \$22,000 per furnace based upon \$4.00 coal or an annual loss of \$22,000 per furnace where the gas is cooled in washing.

In an effort to save this loss many plants burn the gas, at least in the boilers without cleaning. This results in greater boiler capacity from the same amount of gas, but requires more labor blowing tubes and removing dust from the settings, and also loses more flue dust. Used in stoves it precludes any possibility of small checkers or high efficiency stoves and loses about \$2,000 per furnace per year cleaning and heating up stoves. Mr. A. N. Diehl in a paper before the

American Institute of Mining Engineers estimated the total saving of clean gas in stoves to be \$.1591 per ton of iron produced or about \$30,000 per year for a 500-ton furnace. This is due to increased production, increased stove capacity and decreased limestone consumption. While there is \$22,000 worth of heat saved each year per furnace there is more than \$22,000 worth of flue dust, labor and efficiency lost. With high top temperatures encountered in some furnaces in which the flue dust is discarded it may pay to burn raw gas. However, flue dust is now considered valuable in many plants and is charged into the furnaces either raw or treated.

Just recently raw gas from the dust catcher had to be used as a temporary expedient on stoves in a plant in the Pittsburgh District and it was found that the hot blast temperature was 200 deg. F. higher than

when using wet washed gas. Of course as the checkers filled with dust this temperature would drop. If the gas was dry cleaned, retaining the sensible heat and at the same time furnishing clean gas to the stoves, this increase in temperature could be maintained throughout the furnace campaign.

If the gas is dry cleaned the sensible heat is re-

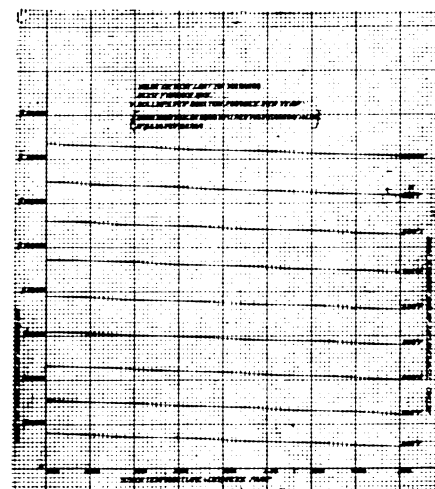


Fig. 2.

tained, more flue dust is recovered than with wet washing, due to elimination of sump loss, there is a saving in power as the dry cleaning requires about one-fiftieth of the power for wet washing, less labor is required, there are no sumps to clean, boiler efficiency is higher

due to more rapid and more thorough combustion, higher initial temperature and the absorption of more heat by radiation. Since combustion is more rapid with hot gas, combustion chambers can be made smaller than necessary for burning cold gas with a given burner. This means lower first cost for buildings and settings. Some flue dust contains a relatively high amount of potash and with wet washing it is next to impossible to recover the potash content unless all of the wash water is evaporated. If the dust is caught dry, however it is commercially profitable to recover

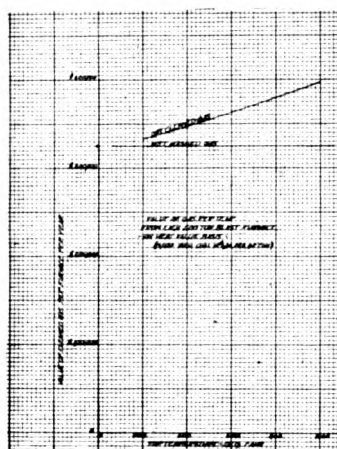


Fig. 3.

the potash content as relatively small amounts of wash water have to be evaporated.

The gas mains and burners in a dry cleaned gas installation after two years of operation were found to be entirely free from dust deposit. This feature alone is enough to cause serious consideration of dry cleaning possibilities, as with wet washed gas sludge deposits in lines and burners until it interferes with operation. This deposit must be removed at fairly frequent intervals and the removal usually interferes with the regular operation.

It has been often suggested that the moisture content of raw or dry cleaned gas, which must be raised to stack temperature upon combustion, more than offsets the value of the sensible heat. The slight slope of the curves in Figure 2 shows in actual dollars and cents the effect of this moisture. In washing gas un-

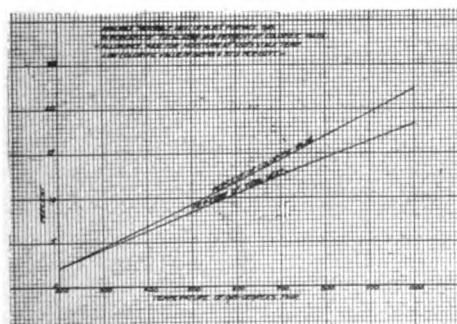


Fig. 4.

less the temperature of the gas is dropped below 112 deg. F. on an average no moisture is precipitated in the washer. The more moisture eliminated the greater is the sensible heat loss in the other constituents of the gas. Tests have shown that in wet washers unless the gas temperature is dropped below the dew point, the moisture content is actually increased due to the

absorption of moisture from the wash water in contact with the hot gas.

Since the average top temperature is about 400 deg. F. and stack temperatures in good stove and boiler practice seldom exceed 550 deg. F. the moisture in the dry gas has to be raised only 150 deg. F. and becomes a negligible quantity.

In addition to the financial return by dry cleaning blast furnace gas there is also the standpoint of the communities in which furnace plants are located and which are supplied by our rivers. Where raw gas is used in addition to the loss out of stacks the flue dust is a nuisance to the surrounding community. The water from the wet washer sumps adds to the chemical and mechanical pollution of the streams by carrying away dissolved salts and iron ore which from a conservation standpoint should be charged into the furnaces. With more stringent smoke and sewage disposal laws

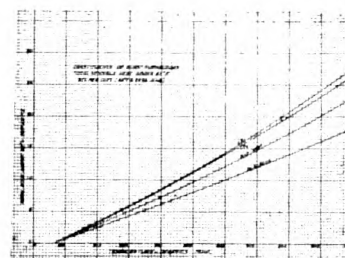


Fig. 5.

the time is approaching when these practices will be prohibited. In locations where water is scarce or the cost of pumping high the dry cleaning process eliminates a serious problem.

Since gas is such an advantageous fuel, requiring less labor and cheaper equipment, and permitting higher combustion efficiency than with solid fuels, efforts should be made to obtain the utmost from it and to eliminate the burning of coal.

The following is an itemized comparison showing the savings by dry cleaned gas over washed gas and over raw gas per year for a 500-ton furnace:

**Comparison of Dry Cleaning vs. Wet Washing or Raw Gas.
Saving Per 500-Ton Blast Furnace Per Year.**

	Saving Per Year Dry Cleaned Gas Over Washed Gas. Raw Gas.	
Saving of Sensible Heat (See Fig. 2) (400 deg. F. Gas—550 deg. F. Stack Temperature)	\$22,000.00	
Fuel Saving Due to Increased Efficiency (5 per cent better eff. from tests of dry vs. wet cleaned gas) (Eff. with rough gas same as with wet—capacity greater)	15,000.00	\$15,000.00
Saving of \$.1591 per ton of iron-cleaned gas over rough		30,000.00
Value of additional flue dust recovered by dry cleaning @ \$.300 per ton.... (47,500 lbs. per day from dry cleaner) (40,300 lbs. per day from wet cleaner) (15,000 lbs. per day from stoves and boilers with raw gas)	3,400.00	13,050.00
Saving in power (75 kw for Wet Washer—1.5 kw for dry cleaner @ \$.01 per kwh)	6,400.00	
Difference in cost of removing flue dust from wet washer sumps and from dry cleaner to stockpile.....	2,500.00	
Saving in blowing tubes (Tubes blown twice a week when using dry cleaned gas)	800.00	1,900.00

Removing dust from settings (Difference between cleaned and raw gas).....		1,600.00
Fuel lost heating stoves after cleaning.....		900.00
Labor cleaning gas mains and stoves.....	500.00	3,300.00
(Does not include value of gas wasted or bled during cleaning mains or loss due to increase in top pressure during period of partial line stoppage)		
Operating labor and repairs—Dry Gas Cleaner less Wet Washer.....	\$50,600.00	\$65,750.00
	1,000.00	1,350.00
Net Total Saving.....	\$49,600.00	\$64,400.00
Based on coal @ \$4.00 per gr. ton; Labor at 30c per hour.		

Above figures are based upon wet cleaned gas of approximately $\frac{1}{4}$ grain dust per cu. ft. and dry cleaned dust of $\frac{1}{2}$ grain per cu. ft.

One-half grain per cu. ft. is not the limit of dry cleaning as blast furnace gas can be dry cleaned to a

given dust content with an installation costing about the same as a wet washing installation for the same cleanliness.

In conclusion it might be said that since the heat saving is only about 30 per cent of the total saving over wet washing, that dry cleaning will prove advantageous in every case of combustion of blast furnace gas with the exception of its use in engines. A dry cleaning plant to reduce the dust content to gas engine requirements would be fairly elaborate and the hot gas would reduce the power of the engines due to the low filling factor of the hot gas, i. e. small weight of gas per stroke. Here the wet primary process in connection with the Theisen washers or equivalent is the only method to be considered unless superchargers are employed. Even with superchargers the power for compressing hot gas to an equivalent weight of cold gas is greater than the power obtained from the sensible heat.

New Flue Gas Filtering System

EVERY boiler operator familiar with CO₂ equipment knows that the first requisite for successful operation is cleanliness and complaint is sometimes heard of the time required for blowing out the gas sampling lines and keeping the mechanism in clean condition. Realizing this situation, the Uehling Instrument Company, 71 Broadway, New York City, have been experimenting with many substances to perfect means for completely excluding soot and dirt from the gas sampling line.

Finally a material combining the necessary porosity and refractory qualities was found and this is now embodied in the new Uehling "Pyroporus" filter, which is placed on the inlet end of the gas sampling line inserted in the flue or last pass of the boiler furnace. This filter consists of a heavy but highly porous disc held in a cup shaped casting by means of a bolt. It is not injured by very high temperatures.

Formerly the gas was withdrawn through an open-ended pipe and the filtering was accomplished with cotton waste; this necessitated more or less blowing out of the gas line and required frequent renewal of the filtering material. With the new arrangement, the soot builds up the "Pyroporus" filter and does not appear to enter the pores to any extent, in fact, many of these filters have been in service for months without ever having been blown out or replaced and without apparently offering appreciable increased resistance to the gas flow.

It is not yet known what life may be expected of these filters, but present indications are that they will last for several years without any attention whatsoever. They are, however, inexpensive, and are easily replaced. To facilitate inspection and replacement the manufacturer has also developed a frame to be inserted in the brickwork and a holder for the sampling pipe which is quickly fastened in place by two bolts. By loosening the nuts on these two bolts and by unscrewing the union at the bottom of the section of sampling line, it requires but a moment to withdraw the filter through the frame. The frame is the width of two bricks, hence it is a simple matter to insert it in the setting without cutting a

large hole in the brickwork. When the sampling line is to be inserted through a metal casing, as with a horizontal tubular boiler, the frame is omitted and the holder is bolted directly to the metal casing of the boiler.

Aside from the great gains in the reduction of attention required on the part of the attendant by the improved arrangement, another very important advantage results, namely, that a smaller pipe line can be employed because its entire cross sectional area is effective when it is kept clean. Smaller pipe is not only easier and more economical to install, but of even greater advantage, it takes less time to draw a given volume of gas through it and consequently the CO₂ recorder reflects furnace operating conditions more promptly when smaller pipe is used.

While designed primarily for Uehling CO₂ equipment, "Pyroporus" filters may be used for other makes of instruments and the frames and holders are useful in connection with pyrometers, draft gauges and for providing convenient openings in the furnace for test and observation purposes.

COKE AS A FUEL.

Floyd Parsons, editor of Gas Age-Record and well-known writer on industrial economics, urges the use of coke as a fuel, he says:

"I am convinced that in the future gas will be manufactured entirely from bituminous coal and that eventually all of the coke will be utilized in the process. In such a practice a ton of coal should produce about 42,000 cu. ft. of 375 Btu gas having a specific gravity of about 55. Gas appliances will be constructed and adjusted to use this grade of gas efficiently.

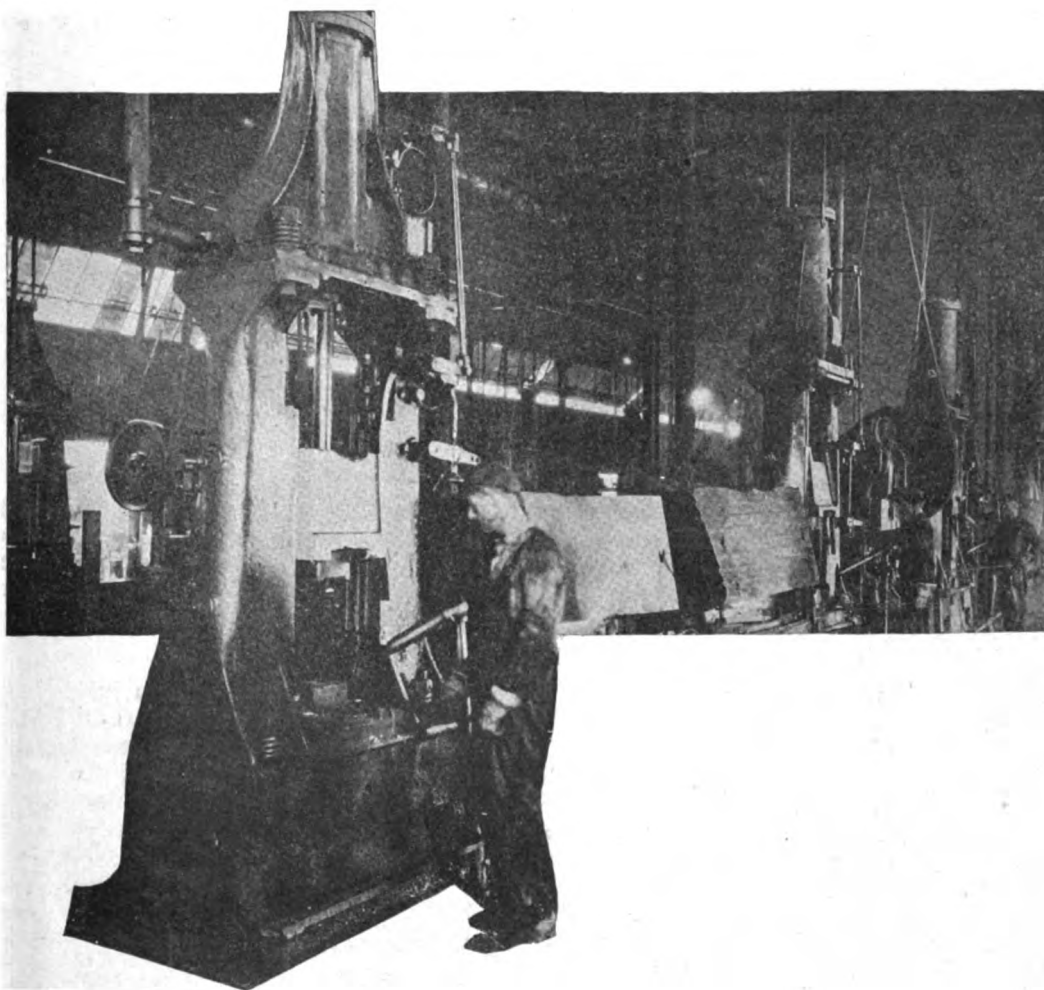
"Heat values can be carried in the form of gas a long distance through a metal pipe more economically than they can be carried in the form of electricity the same distance through the medium of a metal wire or cable. Electricity has a monopoly in the field of energy for power. Gas has an equal opportunity to monopolize the field of energy for heat."

Forging and Heat-Treating Department

Heating Furnaces for Forgings
By C. FISCHER

Effect of Sulphur and Oxides in Ordnance Steel
By WILLIAM J. PRIESTLEY

Refractories in the Steel Plant
By W. A. HULL



Heating Furnaces For Forgings

The Utilization of Waste Gases from Heating Furnaces—Results Obtained Very Surprising When Waste Gases Are Used by Preheating the Steel Direct.

By C. FISCHER

Superintendent Light, Heat and Power, Mesta Machine Co.

THERE are still a number of heating furnaces, using natural gas as a fuel, in operation, which will have to be rearranged sooner or later for the use of a different kind of fuel. The price of natural gas is steadily rising, whilst the output is on the decline, so much so, that one of the large utility companies in Pittsburgh has found it necessary to mix artificial gas with their natural gas in order to take care of the demand.

It seems therefore quite in order that the gas companies distributing and supplying natural gas should start and lead campaigns advocating the conservation of that fuel and educating consumers in the efficient and economic use of the gas.

The results obtained with the various types of forge heating furnaces as to the amount of gas consumed per weight of steel heated vary within wide limits, which fact can be attributed to the different furnace designs and the varying operating conditions in existence.

All furnaces, irrespective of the type and the kind of fuel used, require oxygen for the combustion of the fuel. The oxygen is taken from the air, which is supplied to the mixing apparatus or burner either at atmospheric pressure or by means of fans above atmospheric pressure. The object of the mixer or burner is to thoroughly mix the fuel with the oxygen in the air, admitting only that amount of air, which is necessary for the proper combustion, no more nor less. Too much air carries heat away and not enough air reduces the heat production. The burners obtainable carry out this duty with a varying degree of efficiency, but with a burner properly designed and selected so as to suit the furnace and operating conditions good results can be obtained.

The waste gases leaving the furnaces at high temperatures contain a considerable amount of heat, which in some cases is lost entirely, in other cases is made use of under waste heat boilers, and still in other cases is employed for preheating the air necessary for the combustion.

It is the third application of the waste gases which has been adopted extensively in forge heating and other industrial furnaces, as each furnace with its air preheating chambers becomes a self-contained unit. There is no doubt, that the fuel consumption per weight of steel heated can be reduced by adopting this class of furnace, but whether the total heating costs are very much lower than with the ordinary type heating furnace is not so certain. The first capital outlay and the maintenance of these furnaces with checker chambers are high, the operation has to be skillfully performed, and furthermore it is a difficult matter to

thoroughly mix air preheated to a high degree with the gas, unless further complications in the form of movable burners or mixers are introduced.

It occurred to the writer, that the waste gases could be advantageously put to use by preheating the steel direct, and the results obtained with three furnaces so arranged proved that a step in the right direction was made.

The mean specific heat of steel for various temperatures is approximately as shown in curve below.

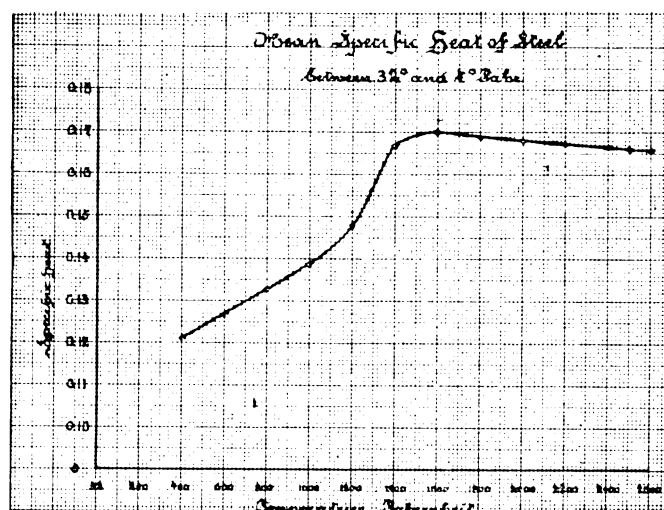


Fig. 1.

The forging temperature is around 2400 deg. F. The mean specific heat of steel between 32 deg. and 2400 deg. F. is about 0.167, therefore the amount of heat required to raise the temperature of one pound of steel to forging heat is:

$$0.167 \times 2400 = 400.8 \text{ Btu.}$$

The actual heat consumed is considerably more and may vary from 1500 to 6500 Btu, according to the type of furnace, fuel and mixing device used. For every pound of steel heated, the heat lost amounts to 1100 to 6100 Btu, this means in dollars and cents:

Fuel.	Cost per Million Btu.	Cost of Heat Lost Per Ton of Steel Heated.
Natural gas	\$0.50	\$1.10 to \$6.10
Manufactured gas	\$0.26 to \$0.42	\$0.52 to \$5.12
Fuel oil	\$0.43	\$0.95 to \$5.25

While it is possible during a test to attain low heat

consumption figures, it is also a fact that test conditions hardly exist over long periods of ordinary operating conditions. During the ordinary operation of a forge shop there occur unavoidable delays which increase the heat consumption and furthermore not every pound of steel heated is forged.

The construction of a double door furnace separated by a wall and connected by means of a flue as shown in Fig. 2 and Fig. 3 is a sketch of two large single door furnaces connected together. Each side or furnace is equipped with a Maxon Premix Burner. This burner consists of a fan driven by a constant speed motor, both gas and air inlets are on the suction side and the volumes are controlled by a simple valve for the gas and a disk shutter for the air. By this means the mixture is always under control and it is possible to obtain and maintain any desirable mixture. The delivery pressure of the mixture is constant, thus being able to keep the furnace under a slight pressure and so prevent infiltration of cold air.

Owing to the circular construction of the furnace the flame has a rotating motion, thus obtaining the longest possible travel of the gases. This feature makes the furnace especially adaptable for heating ingots. A further advantage of this design is the low maintenance cost, no roofs falling in, no checker chambers to burn out, and the doors or frames need not be water cooled. Not only is the simplicity of design of both furnace and burner an outstanding feature, but all complicated operating devices, which may cause delays and breakdowns, thus interfering with the economy and reliability, are practically excluded. Very often special refinements are included in an installation

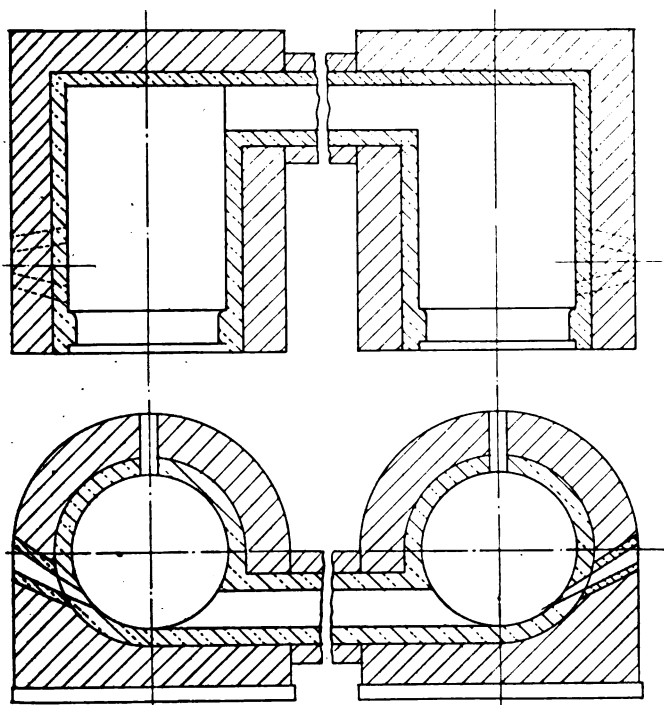


Fig. 2—Two single door forge furnaces for reheating ingots and half finished forgings. The waste gases of either furnace can be used for preheating purposes.

to increase the economy, which, when considered with the installation as a whole, materially increase the risk of delays and shutdowns.

Both sides or furnaces can be charged and the waste gases of either one can be used to preheat the charge in the other. As soon as the finished heat is drawn, the side or furnace containing the preheated material can be brought up to temperature. By closing the damper each side or furnace can be operated independently.

The temperature of the material can be brought up gradually until the critical point is reached, which is between 1200 deg to 1500 deg. Fahr., when the heating can go on more rapidly. Owing to the easy control with which the admitted air can be handled, the surfaces of the steel do not oxidize so readily and the material loss due to this cause can be reduced to a minimum.

The gas consumed, using natural gas as fuel, during the heating period of an ingot of which 45,000 lbs. were heated amounted to 82,500 cu. ft., being 1.83 cu. ft. or about 1830 Btu per lb. of steel heated.

On the basis of the weights of forgings as they leave the forge shop the average amount of gas consumed over a period of one week was 3.5 cu. ft. or about 3500 Btu per lb. of steel forged. The minimum and maximum gas consumption during that period were 2.85 and 4.9 cu. ft. per lb. respectively. The heating and forging operations however were not con-

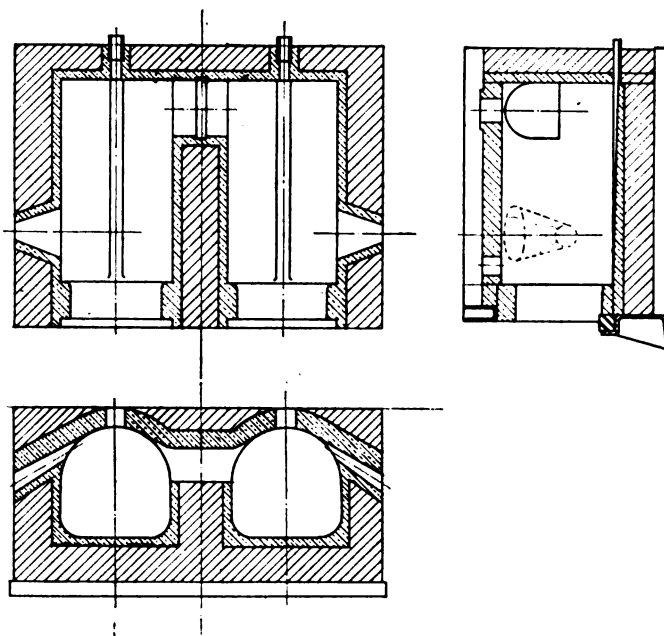


Fig. 3—One double door forge furnace for reheating ingots and half finished forgings. Either side of furnace can be used independently or waste gases of one side can be used for preheating material in other side.

tinuous and the average amounts of gas consumptions mentioned include the gas lost owing to delays. In a forge shop where delays are kept at a minimum and the operation is continuous as in normal times, the heat consumption of 3500 Btu per lb. of steel forged can not only be maintained, but can be reduced with equipment as above described. The heating furnaces have to be of such sizes and construction as to suit the dimensions of the unshaped material, to heat small pieces in large furnaces or vice versa reflects on the efficiency of the furnace.

Effect of Sulphur and Oxides in Ordnance Steel

Describing the Manufacture and Treatment of Steel at the Naval Ordnance Plant, South Charleston, W. Va.—Design of Gun Forgings.
By WILLIAM J. PRIESTLEY

IN THE manufacture of gun forgings and other steel parts that, in service, are subject to sudden high stresses and shocks, it is most desirable to use steel possessing the greatest toughness and ductility possible without sacrifice of strength. In order to obtain this condition, it is necessary to procure steel that shows the highest possible elongation and reduction of area without lowering the tensile strength and elastic limit. Proper heat treatment of the steel can control this condition within certain limits. When heat treatment has failed to produce the desired results, metallurgists have used steels containing molybdenum, zirconium, vanadium, chromium, tungsten, etc.

The purpose of this paper is to describe a method by which these desired physical properties may be procured—by the elimination of certain impurities that inherently exist in steel made by the open-hearth process, and without the use of expensive alloys.

Design of Gun Forgings.

In the manufacture of gun forgings, a certain elastic limit is fixed by the designer, and the walls of the gun are made of the proper thickness, allowing a suitable factor of safety for the high stresses and sudden shocks that occur during gun firing. The elastic strength of the gun is about 1.4 times the stress set up at any point along the bore of the gun during firing with the maximum powder charge.

As the stresses set up in the walls of the gun during firing are mostly "tangential," all physical tests are taken in this direction. Due to the length of the forgings, these tangential test

bars are always taken at right angles and transverse to the direction of flow of the metal in forging. Furthermore, test bars taken across the grain of the metal will more frequently expose defects and foreign inclusions in the steel than will bars taken in the direction of flow of the metal in forging. Impurities in the steel will also be more readily detected by transverse † test bars.

With a fixed tensile strength and elastic limit, a steel with higher elongation and reduction of area is more desirable for service where sudden stresses and great shocks are encountered. The high elongation denotes ductility and the high reduction of area denotes toughness; for the purposes just mentioned, these properties are preferable to a higher tensile strength and higher elastic limit with a lower elongation and lower reduction of area.

Results Obtained with Electric Steel.

Some interesting results were obtained recently in the manufacture of heavy ordnance forgings at the U. S. Naval Ordnance Plant, South Charleston, W. Va. The steel was made by the duplexing process, in which cold charges of pig iron and scrap were melted in a 75-ton basic open-hearth furnace, where the dephosphorizing was done, and subsequently the deoxidizing and desulphurizing was done in two 40-ton basic-lined electric furnaces. A comparison of the physical

The manufacture of ordnance forgings from electric steel is not an innovation. It was tried, during the war, in a number of plants. Some of these plants were not as successful as others, probably because the managers were not sufficiently experienced in the many other phases of manufacture necessary in the making of ordnance forgings.

Steel made in an electric furnace will not be of the best quality unless all operations and reactions are performed completely and satisfactorily. Electric steel with its greater freedom from oxides and non-metallic impurities is more uniform, more homogeneous, and more dense than ordinary open-hearth steel, and if it is cast at too high a temperature or chilled beyond a certain point in the mold, incipient cracks will develop. These minute cracks are radial and are most frequently found near the center of the ingot or forging. Numerous electric-steel plants working on ordnance material, during the war, were troubled with these defects, which from their physical appearance in test bars were called "snow flakes."

A diversity of opinion has always existed between the leading ordnance steel plants regarding the method of teeming steel into the molds. Some have consistently adhered to bottom pouring while others have claimed better results from top pouring direct, or through funnels or boxes. The method apparently makes little difference if the steel is placed in the mold at the proper temperature and has been properly cleansed before teeming. Top pouring direct obviates the danger of getting runner brick into the ingot, which frequently occurs in the case of bottom pouring. It also obviates the danger of sand washing into the molds with the metal from the funnel or box. Bottom pouring will give a better surface on the ingot and for some purposes may be more desirable.

†Tensile test bars referred to here as transverse are taken from the forging in such a manner that their axis is at right angles to the direction of flow of the metal in forging. In the specifications for gun forgings, bars of this kind are referred to as "tangential." The axis of a "longitudinal" test bar is parallel to the direction of flow of the metal in forging.

*Abstract of paper to be presented before American Institute of Mining and Metallurgical Engineers, New York, February 20-23, 1922.

results obtained from forgings made by this process with similar forgings made directly in an acid open-hearth furnace at the works of one of the leading industrial steel plants, noted for high-grade open-hearth steel, shows that the steel with the lower phosphorus and sulphur has the greater toughness and ductility. Transverse tensile test bars from electric steel, though having the same tensile strength and elastic limit as the bars from the open-hearth steel, have a much greater elongation and reduction of area.

The results given in Tables 1 and 2 were obtained on tangential tensile test bars. All forgings received

	Tensile Strength, Lb. Per Sq. In.	Elastic Limit, Lb. Per Sq. In.	Elongation, Per Cent.	Reduction of Area, Per Cent.	Fracture.
Tangential	111,500	55,500	21.3	44.5	Silky lipped.
Tangential	108,500	58,000	20.9	40.2	Irregular and woody.
Longitudinal	109,600	58,500	24.1	55.8	One-half cupped silky.
Longitudinal	109,400	59,700	24.1	56.3	Three-fourths cupped silky.

a green annealing before machining; after machining they were quenched and drawn. For the results given in Table 2, it was impossible to procure comparative results from open-hearth or electric steel made in private industrial plants. The first impression on comparing these results is that the higher elongation and reduction of area are due to the low phosphorus and sulphur, as shown by the chemical analysis; all the other elements are approximately alike.

Effect of Phosphorus.

It would be difficult to draw any comparison between the open-hearth and electric steel in regard to the phosphorus content. This element is in solid solution with the iron as a phosphide and the percentages are too small in both the open-hearth and the electric steel to denote any difference even with a microscope. The lower phosphorus in the electric steel might have a slight effect on the elongation, due to producing a somewhat smaller grain and decreased brittleness in the steel.

Effect of Sulphur.

It has been stated by a recognized authority on the manufacture of steel that "the effect of sulphur on the cold property of steel has not been accurately determined but it is certain that it is unimportant. In common practice, the content varies from 0.2 to 0.10 per cent and, within these limits, it has no appreciable influence on the elastic ratio and the elongation or the reduction of area." This statement probably relates to commercial steels tested longitudinally. In this case the sulphur, in the form of manganese sulfide, has been drawn out into thin shreds in the direction of forging or rolling and is not so easily noticed in the results of longitudinal test bars as it would be in the case of transverse bars. With the overbalancing amount of manganese present in all the steels referred to in this article, probably no iron sulfide is present in the steel for none of the ingots showed any signs of tearing during forging. Steel containing iron sulfide is known to tear in forging and is termed "hot-short" by steelworkers. Manganese sulfide has been described as being present in the ingot in the form of small globules between the grains of the metal. Having about the same fusing point as the metal, these inclusions become equally plastic when the ingot is heated for forging and are drawn out into long, thin

shreds—just as slag is drawn out in wrought iron. If, however, the amount of manganese sulfide present is not enough to form these globules, these shreds will not be developed in forging and transverse test bars will show as good results in elongation and contraction as longitudinal bars.

The following test bars were taken from a piece of this steel. Two of the bars were drilled longitudinal with the forging and the other two tangential. They were given exactly the same heat treatment, quenched at 1425 deg. F., and drawn at 1200 deg. F.; the results were as follows:

It will be noted that the tensile strength and elastic limit are practically equal in the tangential and longitudinal bars, but the non-metallic enclosures in the steel caused the tangential bars to show a lower elongation and lower contraction than the longitudinal bars.

Effect of Oxygen.

There is nothing in the usual chemical analysis to show how much oxygen is present in steel. It exists in small amounts in even the best steel and has bad results. In large amounts, it produces tearing during forging or rolling, and when cold is brittle under shock. If present in steel, it is probably in the form of iron and manganese oxide and silicates. Oxygen is most prevalent in basic open-hearth steel. Where non-metallic enclosures are great enough to analyze, they have been reported to show the following composition: SiO₂ 50 per cent, MnO 30 to 40 per cent, Al₂O₃ 7 to 18 per cent, FeO trace. In the acid open-hearth furnace a more effective reaction between the slag and the steel tends to deoxidize the steel more thoroughly. This cannot be done completely on account of the air present in the acid open-hearth furnace.

A condition exists in the basic electric furnace which cannot exist in the basic or the acid open-hearth furnaces. With a reducing atmosphere in the furnace, it is possible to form a calcium carbide slag free from metallic oxides; with constant rabbling of the bath, any oxides in the steel will rise to the slag, where they are reduced by the carbon present. The iron and manganese are returned to the bath, and the resulting carbon monoxide is liberated to the atmosphere of the furnace. Unless the slag and bath are free from oxygen, it would be impossible to maintain a carbide slag; and unless the slag and bath were thoroughly deoxidized, it would be impossible to retain the sulphur in the slag as calcium sulfide.

Hence, the conditions that bring about the elimination of sulphur from the steel guarantee that oxides and other non-metallic impurities have also been eliminated. This is demonstrated in the case of the last two forgings in Table 1. While the forgings were made by the electric refining process in different steel plants, the test bars of steels containing the higher sulphur, show no better results than the forgings made by the acid open-hearth process. Photomicrographs of the electric steel with high sulphur, reveals more en-

TABLE 1.

	Carbon, Per Cent.	Manga- nese, Per Cent.	Silicon, Per Cent.	Phos- phorus, Per Cent.	Sulphur Per Cent.	Nickel, Per Cent.	Strength, Pounds Per Square Inch.	Limit, Pounds Per Square Inch.	Elonga- tion, Per Cent.	Reduc- tion in Area, Per Cent.
Forging, 16 in. diam. by 9 ft. long, 8½ in. bore; weight 5000 lb. Average results from 10 forgings (or 20 bars) of each class										
Open-hearth steel*	0.36	0.66	0.23	0.04	0.039	2.98	98,013	57,720	20.4	36.9
Electric steel	0.34	0.64	0.22	0.012	0.008	1.16	95,435	64,010	24.5	58.3
Physical requirements.. . .	...	...	...	...	...	...	80,000	50,000	21.0	30.0
Forging, 11 in. diam. by 28 ft. long, 7½ in. bore; weight 6000 lb. Average results from 10 forgings (or 40 bars)										
Open-hearth steel	0.37	0.65	0.21	0.040	0.044	3.02	104,785	73,162	19.6	39.4
Electric steel	0.30	0.67	0.179	0.012	0.009	2.81	96,995	67,785	24.2	55.9
Physical requirements.. . .	...	...	...	...	...	...	90,000	55,000	18.0	30.0
Forging, 9 in. diam. by 28 ft. long, 5½ in. bore; weight 4000 lb. Average results from 10 forgings (or 40 bars)										
Open-hearth steel	0.38	0.64	0.206	0.039	0.040	3.09	103,185	73,231	19.2	39.9
Electric steel	0.34	0.65	0.212	0.014	0.012	2.87	100,340	72,610	23.2	52.5
Physical requirements.. . .	...	...	...	...	...	...	90,000	55,000	18.0	30.0
Forging, 26 in. diam. by 2 ft. long, 5 in. bore; weight 4000 lb. Average results from 5 forgings (or 15 bars)										
Electric steel*	0.37	0.54	0.182	0.020	0.026	2.66	110,182	67,067	17.8	37.1
Electric steel	0.35	0.72	0.169	0.006	0.008	2.91	108,681	77,038	20.2	49.3
Physical requirements.. . .	...	...	...	...	...	...	95,000	65,000	18.0	30.0
Forging, 9 in. diam. by 28 ft. long, 5½ in. bore; weight 4000 lb. Average results from 10 forgings (or 40 bars)										
Electric steel*	0.39	0.53	0.16	0.020	0.025	2.65	95,245	64,979	19.3	37.0
Electric steel	0.34	0.64	0.21	0.014	0.012	2.87	100,340	72,610	23.2	52.5

*These ingots were made by a private industrial plant during the war.

TABLE 2.

	Carbon, Per Cent.	Manga- nese, Per Cent.	Silicon, Per Cent.	Phos- phorus, Per Cent.	Sul- phur, Per Cent.	Nickel, Per Cent.	Chrom- ium, Per Cent.	Tensile Strength, Pounds Per Square Inch.	Elastic Limit, Pounds Per Square Inch.	Elonga- tion, Per Cent.	Reduction in Area Per Cent.
Forging, 17½ in. diam. by 28 ft. long, 10 in. bore; weight 12,000 lb. Average results of 10 forgings (or 40 bars)											
Physical requirements	0.36	0.72	0.224	0.014	0.009	2.90	...	98,225	67,777	25.0	55.3
								90,000	60,000	18.0	30.0
Forging, 22 in. diam. by 11 ft. long, 16 in. bore; weight 6000 lb. Average results of 10 forgings (or 60 bars)											
Physical requirements	0.35	0.74	0.184	0.012	0.009	0.59	...	99,856	63,953	23.9	55.6
								93,000	53,000	18.0	30.0
Forging, 22½ in. diam. by 11 ft. long, 17 in. bore; weight 6000 lb. Average results of 10 forgings (or 40 bars)											
Physical requirements	0.36	0.55	0.206	0.021	0.015	3.14	1.39	140,332	124,182	17.1	48.0
								130,000	105,000	15.0	40.0
Forging, 24 in. diam. by 8 ft. long, 16 in. bore; weight 6500 lb. Average results of 10 forgings (or 20 bars)											
Physical requirements	0.35	0.75	0.214	0.012	0.008	0.52	...	100,195	64,875	24.0	53.9
								93,000	53,000	18.0	30.0
Forging, 32 in. diam. by 2 ft. long, 18 in. bore; weight 4000 lb. Average results of 9 forgings (or 27 bars)											
Physical requirements	0.35	0.70	0.172	0.008	0.009	2.97	...	102,509	71,572	22.4	53.8
								95,000	65,000	18.0	30.0

closures than the electric steel with low sulphur.

Manufacture of Steel at Naval Ordnance Plant.

From the foregoing physical results and substantiating data, it is evident that the presence of sulphur, oxides, and other non-metallic enclosures are detrimental to the ductility and toughness of steel. Where the best quality of steel is required, it is necessary to keep these impurities to a minimum. The basic open-hearth furnace eliminates the phosphorus but only slightly reduces the sulphur; the oxides must be eliminated by the addition of deoxidizers, such as ferro-manganese, ferrosilicon, aluminum, etc., which are sometimes added to the open-hearth furnace and rabbled after the air is shut off but more frequently are added to the metal in the ladle. If added in the ladle, the reactions are incomplete and the products of combustion remain suspended in the steel, forming harm-

ful non-metallic inclusions. Gun forgings and other ordnance material, where transverse tests are required, have never been successfully made from basic open-hearth steel. The bars generally fail in elongation and reduction of area tests, because of the presence of these inclusions. They generally break with a laminated and woody fracture.

The acid open-hearth furnace is better for making steel free from oxides and non-metallic impurities, and ordnance forgings have been obtained from acid open-hearth steel. While neither phosphorus nor sulphur can be eliminated in this furnace, the amount of these impurities may be kept down by the selection of high-grade scrap and pig iron. The oxides may be largely eliminated by the effective reaction between the slag and the steel.

The method of making steel at the U. S. Naval

Ordinance Plant aims for the elimination of phosphorus, sulphur, and oxides. The metallic charge of the open-hearth furnace consists of 40 per cent. basic pig iron and 60 per cent miscellaneous scrap, including turnings, crop ends, etc., up to 8 per cent of limestone is added with the charge and sufficient ore to lower the carbon to approximately 0.20 to 0.25 per cent, which is slightly below the amount required in the finished steel.

The pig iron has the following approximate analysis: Carbon 3.50 to 4.00 per cent, manganese 0.95 per cent, silicon 0.65 per cent, phosphorus 0.15 per cent and sulphur 0.04 to 0.05 per cent. The crop ends are usually low in phosphorus and sulphur, being the discard from ingots made at this plant by the electric refining process. The miscellaneous scrap, consisting of boiler plate, punchings, and turnings, average approximately 0.04 to 0.05 per cent phosphorus and sulphur.

The limestone shows the following analysis: SiO_2 1.43 per cent, $\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$ 0.60 per cent, CaCO_3 97.54 per cent. A small quantity of fluorspar added to the slag has a negligible effect upon the analysis.

The average analysis of the final slag taken from the open-hearth furnace on nineteen consecutive heats just before tapping is as follows: SiO_2 15.43 per cent,

SiO_2 , Per Cent.	Fe, Per Cent.	Al_2O_3 , Per Cent.	Mn, Per Cent.	CaO, Per Cent.
15.10	0.64	1.98	0.27	58.24
8.16	0.70	3.32	0.11	64.01
11.97	0.66	1.74	0.53	57.95
9.20	0.58	4.39	0.40	61.76
4.32	0.74	2.63	0.14	63.11
17.60	0.49	3.26	1.05	58.32

FeO 19.27 per cent, Al_2O_3 3.66 per cent, MnO 8.02 per cent, CaO 45.02 per cent, MgO 6.37 per cent, P_2O_5 1.80 per cent, S. 0.031 per cent.

The average analysis of the steel prior to tapping these same heats was as follows: Carbon 0.23 per cent, manganese 0.26 per cent, silicon 0.010 per cent, phosphorus 0.007 per cent, sulphur 0.015 per cent, nickel 0.66 per cent, chromium 0.00 per cent. After it is tapped from the open-hearth furnace into a 75-ton ladle, the steel is teemed through a $2\frac{1}{2}$ in. nozzle into two 40-ton basic electric furnaces for deoxidizing and finishing. Usually 2 lb. of 50 per cent ferrosilicon and 3 oz. of aluminum for every ton of steel tapped from the open hearth are added to the ladle, to take up any oxygen present, which might lower the carbon content while the steel was in the ladle.

An average analysis of the slag in the ladle from the nineteen heats, after teeming into the 40-ton furnace was as follows: SiO_2 17.27 per cent, FeO 18.32 per cent, Al_2O_3 5.75 per cent, MnO 7.84 per cent, CaO 42.79 per cent, MgO 8.15 per cent, P_2O_5 1.65 per cent, S 0.028 per cent.

The average analysis of the metal as teemed into the electric furnaces from the open hearth on the same heats was as follows: carbon 0.20 per cent, manganese 0.23 per cent, silicon 0.037 per cent, phosphorus, 0.007 per cent, sulfur 0.016 per cent, nickel 0.67 per cent, chromium 0.00 per cent. Both the furnace and the ladle slags show a slight increase in silica and alumina, which may be caused by the addition of the ferrosilicon and aluminum into the ladle. Some of these same elements may have been washed from the sides of the ladle and floated up into the slag. A comparison

of the steel analysis will show that the silicon increased slightly; also, that there was a slight drop in carbon and manganese while the steel was in the ladle. The average phosphorus content of the charge into the open hearth was about 0.08 per cent, because of the comparatively low phosphorus in the crop ends.

After teeming the molten open-hearth steel into the 40-ton electric furnaces, a new slag is made up of burned lime, fluorspar, and ground coke. This represents, in weight, about 3 per cent. of the metal charged and is added from time to time, depending on the condition of the bath and the consistency of the slag. The operation from now on is a deoxidizing one. Under normal conditions, the bath is held from 3 to 5 hr. in a reducing atmosphere. The burned lime used in making up the new slag from the electric furnace showed the following analysis: SiO_2 2.50 per cent, $\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$ 1.50 per cent, CaO 68 per cent, MgO 20 per cent; loss on ignition 8 per cent. The MgO content is higher than usual, but a local lime is used for economic reasons; regular practice limits the MgO content to 5 per cent.

The final slag from the electric furnaces, after finishing the steel, showed the following approximate analysis on six consecutive heats:

MgO , Per Cent.	P, Per Cent.	S, Per Cent.	CaC_2 , Per Cent.
16.13	0.020	0.281	1.23
16.98	0.067	0.281	1.14
14.53	0.082	0.188	0.97
12.77	0.044	0.360	1.31
16.21	0.016	0.393	1.30
13.28	0.030	0.337	1.33

The high MgO in these slags comes from the high MgO in the lime used. The low sulphur is caused by the low sulphur in the charge. The high basicity of this slag and its freedom from metallic oxides, compared with the slag from the open-hearth furnace, should be noted. Unless the slag and steel are thoroughly deoxidized, it would be impossible to form the carbide slag, without such a slag, it would be impossible to eliminate the sulphur from the steel.

The finished steel on these same six heats showed the following analysis:

Carbon, Per Cent.	Manganese, Per Cent.	Silicon, Per Cent.	Nickel, Per Cent.	Phosphorus, Per Cent.	Sulphur, Per Cent.
0.32	0.71	0.250	0.36	0.022	0.009
0.36	0.74	0.241	3.03	0.013	0.008
0.29	0.74	0.238	2.78	0.010	0.007
0.35	0.71	0.200	0.31	0.013	0.008
0.38	0.67	0.210	2.97	0.010	0.008
0.30	0.78	0.215	2.83	0.013	0.010

The low sulphur in the final slag denotes the possibility of removing a greater amount from a steel of higher sulphur content from the open hearth. This would result from using a lower grade of scrap and pig iron with higher sulphur content in making up the charge for the open-hearth furnace. This might occur in plants where miscellaneous scrap is purchased in the open market and where crop ends are not so low in sulphur as those at this plant.

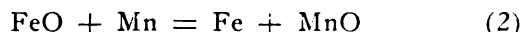
Description of Reactions.

The reducing atmosphere and high temperature

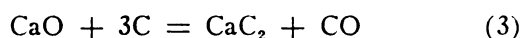
existing in the electric furnace permit the following reactions: When the molten steel comes from the open hearth, it contains oxides, principally in the form of FeO and MnO. As the MnO is less soluble in the molten metal than the FeO, it rises to the slag, which has been added on top of the steel as teemed into the electric furnace. This slag contains CaO and C. As the MnO rises to the slag, the following occurs:



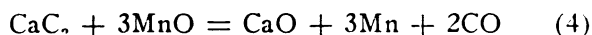
The Mn goes back to the bath and the CO is liberated as a gas. When the Mn goes back to the bath, the following reaction takes place:



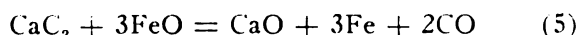
Reaction (1) again takes place. When this reaction is complete and all metallic oxides eliminated from the slag, another reaction between the lime and carbon takes place, in which calcium carbide is formed:



This reaction, however, will not be stable as long as there is a migration of either MnO or FeO from the bath to the slag. In this case, the following occurs:



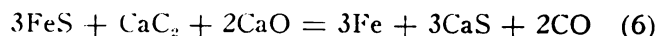
or



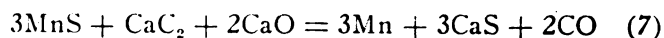
As long as the slag retains its carbide condition after

repeated rabbling, it may be assumed that the bath has been freed from oxides. When reaction (3) becomes stable, it is possible to eliminate the sulphur from the steel.

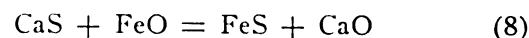
The sulphur is present as FeS and MnS. As calcium has a greater affinity for sulphur than either Fe or Mn, its presence in the slag causes the following reaction:



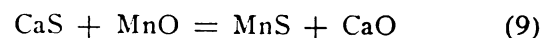
and



The Fe and Mn return to the bath, the CO goes off as a gas, while the CaS is held in the slag. If for any reason the slag should take up any metallic oxide, the conditions expressed in equations (6) and (7) would be reversed and the calcium would give up the sulphur as follows:

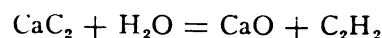


or



A simple test for the presence of CaC₂ in the slag may be made by sprinkling water on the slag.

Acetylene gas is given off as a result of the following reaction:



Refractories In The Steel Plant*

General Discussion Dealing with the Investigations Made on Refractories During the Past 20 Years—Necessary to Establish Suitable Specifications.

By W. A. HULL

Chief of the Refractories Section Bureau of Standards, Washington, D. C.

IF THE manufacturer who uses refractories can count on a furnace for the term of uninterrupted production, which experience has established as reasonable, then he can co-ordinate that furnace with the rest of his plant unit and depend on uninterrupted production. It goes without saying, that any addition to the established life of the furnace is a distinct gain, but the vital thing is immunity from the unexpected shutdown. The dread of the production man is the lot of brick that will not go the distance, and his complaint when he finds evidence of nonuniformity in an established brand of fire brick comes from the heart.

The question of price is one of the big stumbling blocks in the way of improvement. It is, perhaps, not going too far to say that the greatest transgressor in delaying progress is the purchasing agent. Not until the information gained by the production man and the metallurgist penetrates to his sanctum in sufficient quantities to produce an effect can the refractories question be said to be on a fair way to a satisfactory solution. Progress

*Abstract of paper presented before American Iron and Steel Institute, New York City, November 18, 1921.

has already been made in this department, but the more rapidly it becomes general, the better.

One of the great handicaps of the purchasing agent is the almost total lack of specifications. Both manufacturers and consumers of refractories have been rather gun shy on this point; and in the writer's judgment it is one of the things that they will have to come around to and get together on in order to make the best speed. Up to this time the matter of specifications has been left too much to the fire brick manufacturers; and their tendency is to make specifications fit the brick which they make, and with which they are familiar, rather than to make them to fit service requirements. Obviously this is putting the cart before the horse; for the purpose of a specification is to secure a quality that will meet a definite requirement. In refractories, as in other things, the user is in a better position to describe what he requires than is the man who proposes to make the article. If the user makes a specification that simply corresponds to the material which he is already obtaining, it will, of course, serve a certain limited purpose, but if he knows the qualities actually required for a given service and can describe those qualities in terms of a few simple

tests, he can draft a specification that will bring in the kind of brick he wants. It may not be on the market when the specification is made, but if it represents an established demand for any large tonnage of refractories, it will furnish a definite goal worth working for. There is a definite service to be performed by the specification that is simply set up to shoot at. If it is anything within reason, somebody is going to hit it, simply because it is there to aim at. Of course, the user must actually buy brick on specifications that can be met at once, but they should not be drawn to the level of what the majority of producers are turning out. Another important point is to keep the number of specifications small so that the producers can market a large tonnage of brick made to one specification. In order to carry this principle to its logical conclusion, the specifications of different consumers should be unified as far as possible. The refractories producers can co-operate effectively in this, and there is no doubt that they will; but there is a tendency which has been found to prevail in many cases which must be guarded against. This is the tendency to hold the specification down to the level of the average producer or even of the tail-end.

The Bureau of Standards is the logical clearing-house to serve both consumer and producer in the preparation and unification of specifications. It can, perhaps, be of greater service to consumers than to producers because the former are less united and their problems are so diversified. The Bureau is now working in co-operation with consumers, distributors and producers on the preparation of specifications for certain materials. It is surprising how many important commodities are being bought without specifications and how much difference is found in the quality of different makes of the same article, all of which look to be substantially alike. There is no question that in certain lines some manufacturers are making and marketing an inferior product without knowing it, simply because no standard of quality exists.

Granting that a specification should be made to conform to the service requirement, the first essential to the preparation of any specification is a knowledge of the properties in the refractory which determine its life under the given conditions. The fact that specifications are not now available is probably due, not so much to a lack of appreciation of their potential value, as to an underlying uncertainty as to the application of any proposed set of test requirements in actual service. A test, in order to be of practical value, must be one that can be made conveniently and in a comparatively short time. In actual service, the fire brick must last a comparatively long time. It naturally follows that the tests considered in connection with proposed specifications are what are called accelerated tests—something that will determine a given property of the material rather quickly. This in itself demands a departure from service conditions. Also, there are a good many agencies affecting the life of a brick in service which it would be extremely difficult to duplicate in anything except in actual service test. For example, it would require a good deal of preliminary research to make it possible to approximate in a test the destructive action of the fluxes in the atmosphere of an open hearth furnace or an electric furnace. Testimony has been given by prominent men outside the steel industry to the effect that they have found important differences in the service of different grades of brick which they have not been able to connect with differences in their properties, as shown by any of the tests that they have applied.

In other lines than refractories, extended research

has been found necessary to the preparation of suitable specifications. For example, the Bureau of Standards has recently prepared, after much preliminary work, a specification for leather belting. In the course of the study of this problem a number of surprises were encountered, one of which was that the best belting was not the strongest. In the case of refractories, it has long been recognized that the most refractory brick are not the best for all purposes and that there was much to be learned about the relation of other determinable properties to service requirements. The work of the Bureau, up to this time, has been devoted largely to the study of some of these properties and the development of tests for determining them. A portion of this work has already been referred to, but it seems worth while to consider it somewhat more in detail.

One of the first and most fundamental of the investigations taken up was that reported in Technologic Paper No. 10, on the "Melting Point of Fire Brick," by Dr. C. W. Kanolt. In this paper a scientific discussion of the problem, including a consideration of the fact that fire brick do not have a true melting point, is to be found. Determinations were made of the melting points of 62 samples of fire brick and of materials of importance in the manufacture of fire brick. These samples included fire clay brick, bauxite brick, silica brick, magnesite brick, cromite brick, kaolin, pure alumina, pure silica, bauxite, bauxite clay, and chromite. Temperatures were measured with an optical pyrometer. An improved method of calibrating optical pyrometers is described. It is needless to call attention to the importance of the fundamental data furnished by a work of this kind when done in the thorough and painstaking way in which this was done.

Although a correct knowledge of the melting points of refractory materials is of fundamental importance to investigators, it was realized, by those studying problems connected with refractories, that the ability of a given grade of brick to stand up at a given temperature under furnace conditions, could not be judged within sufficiently close limits by the melting points. Due to viscosity, some materials would preserve their form in a fusion test at temperatures higher than they would stand in a furnace where they were subjected to at least a moderate load. In order to develop a test which would more nearly approximate service conditions and be of value in the practical testing of refractories, a large amount of work was done by the Bureau and was reported in Technologic Paper No. 7, by A. V. Bleininger and G. H. Brown. This report is entitled: "The Testing of Clay Refractories, with Special Reference to Their Load Carrying Ability at Furnace Temperature." General consideration of the refractoriness of fire clay bricks, their viscosity at furnace temperatures, nature and manufacture of refractory clays, effect of accessory constituents upon softening temperatures, effect of fluxes on refractories, effect of heat upon dehydration, contraction, crystallization, and load carrying capacities, are included as well as a large amount of test data. A brief summary of the conclusions includes the following points:

Referring to a clay material which is sufficiently plastic so that no bonding material is necessary, it is stated that "a pure clay of moderate plasticity would be the ideal material for the manufacture of fire bricks." It was found that at the temperatures employed, the presence of even a small amount of fluxes becomes a potent factor and the superiority of a clay high in silica and low in fluxes over one possessing the silica-alumina

ratio of kaolin, but higher in fluxes, was shown. The danger of the combination, including both high silica and high fluxes, was pointed out, as was the importance of the size of grain. The importance of the effect of fluxes on the ability of refractories to carry load was emphasized.

In regard to grog, or pre-burned clay, we find the following statement: "Its function from the standpoint of load-carrying ability is two fold: By proper sizing it may be made to improve the mechanical strength of the product; by using grog, consisting of high-grade clay and grinding part of it fine, the standing up quality is improved."

In connection with the consideration of the manufacture of refractories from flint and bond clay, the following recommendations were made:

"If a flint bond clay mixture should prove unsatisfactory as regards its ability to carry loads, the first step would be to cut down the amount of plastic clay, if possible. If this should not be feasible or beneficial, the plastic material would be improved by grinding it intimately with a portion of the flint clay to such a degree of fineness as would insure thorough incorporation. This could be done by dry, or preferably wet grinding. In the latter case it might be possible to pug the additional coarser flint clay into the slip, which naturally would be maintained as thick as possible. The finely ground flint clay would not remain inert, but would of course develop some plasticity."

"By paying attention to the sizing of the ground clays so as to produce as dense a structure as possible, by the use of less water and by adopting dry pressing, the load carrying capacity of the fire bricks would be increased. Likewise, burning at as high a temperature as possible assists in bringing about the same result. Experiments carried on by the writers have shown that harder burning has increased the strength of fire bricks appreciably.

"Unfortunately, the users of refractories do not realize the cost of producing high grade ware, but insist upon low prices, which do not permit the manufacturers to exercise that care in the selection, mixing, sizing and burning of the products which is necessary for the best results. It is self evident that this is poor policy as the initial cost of the refractories is very small compared with that of repairs and the loss caused by shutdowns."

One of the points brought out in the discussion of specifications, which follows, is that for many purposes, products of No. 2 grade are far more suitable than the more expensive high class refractories. It is believed that the importance of this fact is much more generally realized in 1921 than it was in 1911, when this paper was published.

In connection with the recommendations made in this paper as to the mixing of fine ground flint clay with the less refractory bond clay, to improve the refractory qualities of fire clay bricks, it should be noted that at this time bricks are being made for a trial lining for a blast furnace at Cleveland, Ohio, in which this principle is being carried out. A portion of the bond clay for these bricks is replaced by bauxite. The material used is a waste product of bauxite mines. The amount used represents approximately 10 per cent of the total raw batch. The results of this service test will be watched with much interest.

At the end of this paper on load testing, the authors submit a set of suggested specifications for three grades

of refractories. These will be given in detail further along in this paper in connection with other specifications.

The following investigations made by the Bureau, while of more general application than the foregoing, are of value in connection with the study of refractories for various purposes:

Technologic Paper No. 17—"The Function of Time in the Vitrification of Clays."

Technologic Paper No. 2—"The Effect of Overfiring on the Structure of Clays."

Technologic Paper No. 23—"Use of Sodium Salts in the Purification of Clays and in the Casting Process."

Another investigation of importance was reported in Technologic Paper No. 79, "Properties of Some European Fire Clays," by Bleining and Schurecht. This was published in 1916. The properties of five well-known European fire clays used in the manufacture of glass, refractories, graphite crucibles, etc., were studied. Methods that had been developed in the Bureau for attacking problems of this sort were employed. The content of shrinkage and pore water, the drying shrinkage, fineness of grain, mechanical strength in the dry state, the Atterberg plasticity number, rate of vitrification and softening temperature were determined. A comparison of these materials as to their suitability for several purposes, was given, and tentative specifications were suggested for the selection of clays which might be used as substitutes for these foreign materials. American clays are available which, if used as mixtures, can take the place of the imported clays with equally as good or superior results.

In Technologic Paper No. 104, "The Effect of Size of Grog in Fire Clay Bodies," the following findings were reported:

The effect of the size of the calcined portion, or grog, upon the properties of the fire clay bodies is as follows: Strength of the raw body depends upon a number of factors and does not vary with the size of the grog. Strength of burned bodies increases directly with decrease of the size of grog. In quenching tests from 600 deg. C. and 1000 deg. C. mixtures of the larger sizes of grog gave the more resistant bodies. Application of results and European practices are given brief consideration in this report.

The large amount of data on the properties of American bond clays is given in Technologic Paper No. 144, "Properties of American Bond Clays and Their Use in Graphite Crucibles and Glass Pots," by A. V. Bleining.

"The physical properties of three typical German clays formerly imported in large quantities were described in detail and on the basis of constants, which make possible accurate comparison and evaluation of American materials. Similarly the physical characteristics of 23 American and 2 English bond clays were determined. Of these, several approach the Klingenberg and Grossalmerode clays quite closely. Others by suitable blending can be made to equal or excel the European clays."

It is stated in this paper that for crucible making the best clays should show a pore shrinkage water ratio of not more than 1:1; a modulus rupture for a clay sand vitrification point of 1150 deg. C. or lower; no marked evidence of overfiring at 1400 deg. C., and a softening point corresponding to Orton cone 31, or above. For glass pots, the best materials should show a pore shrink-

age water ratio of not more than 1:1; a modulus of rupture, when mixed with equal weights of sand, of not less than 250 pounds per square inch; a vitrification temperature of approximately 1275 deg. C.; an overfiring temperature not below 1425 deg. C., and a softening point equivalent to Orton cone 29, or above.

An extremely comprehensive piece of work and one having an important bearing on the matter of specifications, is that reported in Technologic Paper No. 159, by G. A. Loomis, entitled "Porosity and Volume Changes of Clay Firebricks at Furnace Temperatures." In this paper the methods of test for refractories already in use are discussed. Sixty-one kinds of brick from different sections of the country, made by different processes, were studied. Changes in porosity and volume taking place in these refractories when heat treated at temperatures up to 1450 deg. C. are given. The behavior of the different bricks as change in volume and porosity is correlated with the behavior in the load tests and with their softening points.

The following discussion of the application of porosity and volumes change determinations on fire clay bricks, is given:

"The determination of porosity or volume changes of fire clay bricks, burnt at some temperature between 1350 deg. and 1425 deg. C. affords a means of separating a certain proportion of bricks which would fail in the load test. The limits of 3 per cent in volume change (or 1 per cent in linear contraction or expansion) and 5 per cent decrease in porosity at 1400 deg. C. do not eliminate all bricks which cannot withstand such a test, but materially reduce the number which would require such testing. In this respect it would be of considerable advantage in comparing the quality of a large number of samples, since the porosity and volume changes may be determined readily from a single burn in a test kiln. To make standard load tests on a number of bricks requires considerable time and expense, even if several furnaces were available.

"The determination of volume changes is comparatively simple when porosities are also determined, since the difference in the wet and suspended weights of the specimens affords a measurement of volume practically as accurate as by means of the volumometer.

"The porosity and volume changes in burning may also be used advantageously as a means of determining the uniformity of quality of a lot of bricks of a single brand. The behavior of such bricks should be fairly uniform if they be of equal quality. Such application of these measurements would be of value to the manufacturer as well as to the consumers.

"A study of the curves for porosity and volume changes for a series of burning temperatures offers a means of determining, in some measure, the causes of failure of certain bricks in the load test. If this is due to underburning, resulting in excessive deformation under load due to shrinkage, a considerable decrease in porosity and volume will be found at the lower burning temperatures. Clays of inferior quality which overburn will be detected by marked expansion at some point in the burning, usually accompanied at a somewhat higher temperature by an increase in porosity due to vesicular structures, show gradual but marked contraction and decrease in porosity as the burning temperature is increased."

The results of the work are summarized as follows:

1. Bricks which are capable of withstanding a pres-

sure of 40 pounds per sq. in. at 1350 deg. C. generally show slight changes in volume or porosity when burnt at temperatures below 1425 deg. C.

2. The greater number of the bricks which failed to pass the load test show rather marked change in volume or in porosity at some temperature below 1425 deg. C.

3. Bricks which show distinct overburning by pronounced expansion at temperatures below 1400 deg. C. invariably fail in the load test. The adoption of a definite limit for the permissible expansion within the given temperature range is particularly important for detecting inferior clay refractories. The limit of expansion should be lower than that for the allowable contraction.

4. The changes in volume and in porosity of bricks burnt at some temperature between 1350 deg. C. and 1425 deg. C. serves, in a measure, as a criterion of their ability to pass the load test.

5. Most of the bricks which show a porosity decrease not exceeding 5 per cent and a volume change not exceeding 3 per cent (approximately 1 per cent in linear dimensions) when burnt at 1400 deg. C. will pass the load test.

6. Bricks which show a decrease in porosity exceeding 5 per cent or an expansion or contraction in excess of 3 per cent by volume (1 per cent in length) at 1400 deg. C. in nearly all cases failed to pass the load test.

7. The use of limiting porosity and volume changes for clay fire bricks burnt at 1400 deg. C. would serve as a means of eliminating from consideration a large number of bricks which fail in the load test.

8. Bricks which fail in the load test due to failure in the bond may not show marked changes in volume or porosity in burning, but often show very low cold crushing strength.

9. No definite relationship seems to exist between the softening point of a fire brick and its ability to withstand load at high temperatures. However, all bricks which softened below cone 28, whether silicious or not in character, failed completely in the load test. It seems advisable then to specify cone 28 as the minimum softening point for any clay fire brick. It is probable that bricks containing less than 65 per cent SiO_2 should have a minimum softening point of cone 31.

10. Bricks with an initial porosity below 21.5 per cent and with an average decrease of about six points in percentage of porosity, contracted about 5.5 per cent in the load test. Bricks showing an average porosity above 21.5 per cent showed a like contraction in the load test with a change of about three points in porosity percentage.

The foregoing paragraphs treat exclusively of fire clay refractories. Next in importance come silica refractories and some extremely good work has been done in the study of the properties in behavior of these materials. The major part of that done by the Bureau has been reported in Technologic Paper No. 116, by D. W. Ross, entitled "Silica Refractories—Factors Affecting Their Qualities and Methods of Testing the Raw Materials and Finished Ware," and Technologic Paper No. 124, by Insley and Klein, entitled "Constitution and Microstructure of Silica Brick and Changes Involved Through Repeated Burnings at High Temperatures."

Important contributions on this subject made by Fenner of the Geophysical Laboratory, and McDowell of

the Harbison-Walker Refractories Company, and by others, are referred to in these papers.

Technologic Paper No. 116 covers the subject of silica refractories in a rather comprehensive way, dealing with the raw materials in different sections of the country, with problems of manufacture, and the use of silica refractories, methods of test as well as technical matters connected with the composition of these refractories, the transformations occurring in the burning and the bearing of these transformations on behavior in use are treated at considerable length. The results of a large amount of work on the effect of burning silica refractories of various compositions at different temperatures, and for different lengths of time, are given. The results of a study of resistance to slag action are also included. The author's summary follows:

"In conclusion, it may be said that in general the most satisfactory quartzites for silica refractories are those which contain not less than 97 per cent of SiO_2 , nor more than 0.40 per cent of alkalis, and are made up of tightly interlocking grains. The geologic age of quartzites actually used in the manufacture of silica brick in the United States at the present time ranges from cretaceous to pre-cambrian. The harder portions of the Medina formation in Blair and Huntingdon Counties, Pa., have proved to be particularly suited for steel furnace work. Approximately 60 per cent of the silica brick manufactured in the United States at the present time is made of this material. The balance comes largely from the Baraboo formation of Wisconsin.

"Raw brick made from such quartzites should not show undue increase in pore space on being repeatedly burned in a commercial kiln to approximately 1350 deg. C. Two limiting factors in the use of quartzites are impurity, resulting in low softening temperature and friableness, which results in weak brick. Amorphous silica, chert, and chalcedony, when in solid rock form and of desired purity, may also be satisfactory for the manufacture of silica brick, but as yet have not been thoroughly tried out in the United States. Their rates of transformation on being heated are, however, appreciably greater than that of quartz. Hence they should be heated more slowly to prevent their disruption.

"As now manufactured, the usual upper limit in the size of fragments present in silica refractories is slightly more than $\frac{1}{4}$ -inch diameter. In the case of brick made from Medina quartzite, those containing coarse fragments tend to spall less than those made of finer material. The slagging effect produced by many basic slags should be kept at a minimum by low porosity, large fragments and by using quartzites having tightly interlocking grains.

"It is probable that the nonuniformity of finished brick, due partly to present methods of grinding of mix and molding of bricks, may in special cases be somewhat minimized by crushing the quartzite in a dry pan to the proper size, screening, then mixing in proper proportions in a mechanical mixer similar to a concrete mixer, which will not further crush the material, and finally molding by machinery under a pressure of approximately 1500 pounds per square inch. This would also improve shape and finish of the brick.

"In the burning of silica brick, the volume of the solid material increases from 10 to 15 per cent of its own volume, owing to the transformation of quartz to the lower specific gravity forms of silica, but since the average porosity of such brick is approximately 26 per cent the exterior volume expansion of the brick will be some-

what more than this. The porosity of a well-burned brick is usually greater than that of the raw mix. In silica refractories there is but a small percentage of flux; hence in burning the quartz is transformed directly to cristobalite. However, when approximately 70 per cent of the material has been converted to cristobalite, tridymite makes its appearance and is developed slowly with continued heat treatment, gradually reducing the amount of cristobalite present. A few per cent of quartz plus silicate glass remain, however, even at a very advanced stage of burning. This is probably mostly silicate glass. In the usual silica brick mixes containing 2 per cent of lime the transformation to forms of lower specific gravity is very slow below 1350 deg. C., but above that temperature, and at a temperature of 1500 deg. C. a close approach to minimum specific gravity is reached in a couple of hours. With a given heat treatment at temperatures from 1200 deg. to 1350 deg. C., the 2 per cent of lime causes the quartz to be transformed much more rapidly than is quartz alone. Greater percentages of lime accelerate transformation still more. The presence of lime in silica refractories causes their softening temperature to be much more clear cut, because of increased fluidity, than is that of pure quartz.

"In burning, to produce a brick of low porosity and low specific gravity, the temperature should be gradually raised to approximately 1250 deg. C. and held between that temperature and 1350 deg. C. for several days to insure transformation of quartz at a moderate rate, and at the same time obtain the effect of soaking. The temperature should then be gradually raised, so that the maximum of the heat treatment is approximately equivalent to cones 18 to 20. Such treatment should produce a brick containing a considerable percentage of tridymite. However, the production of a brick composed entirely of tridymite appears to be impracticable commercially. Rapid rising of the temperature from 1250 deg. C. on, tends to produce undue increase in pore space.

"Since most commercial silica brick are largely cristobalite, their chief spalling tendency is at the alphabeta cristobalite inversion (220 deg. to 275 deg. C.) Also such brick, when heated as in the load test, show a very marked volume expansion at this temperature range, then a gradual but very small additional expansion continues to take place with rise of temperature, until a temperature of approximately 1400 deg. C. is reached, at which point expansion due to transformation of any unaltered quartz present in the brick becomes apparent on the expansion curve. This latter expansion will appear as the permanent expansion when the brick is cold. Thus, it is rather difficult to state the coefficient of expansion of silica brick as a single figure.

"Since check heat treatments of silica brick are difficult to make, the only satisfactory way of actually comparing the amount of expansion of different varieties is to use a heat treatment which is sufficient to insure approximately minimum specific gravity. The specific gravities of practically all commercial silica brick lie between the limits of 2.650 and 2.270. The relative positions between these two points of the specific gravity of a brick, as it comes from the manufacturer, clearly denotes the degree of burning which it has received in manufacture, and in conjunction with the porosity indicates approximately how much the brick will subsequently expand in use.

"The use of silica refractories is limited largely by the degree to which the quartz grains are bonded together in the fragments and by the degree to which the fragments are bonded in the brick.

NEWS OF THE PLANTS

The Whitaker-Glessner Company, Portsmouth, Ohio, has completed plans and will soon commence the erection of a one-story addition, to be equipped as a rod mill. It is estimated to cost about \$50,000. Headquarters of the company are at Wheeling, W. Va. H. Bowman is chief engineer.

The Merchants' Dispatch Transportation Company, Rochester, N. Y., is completing plans for the erection of an addition to its steel fabricating plant at East Rochester, to be one-story 60x85 feet. It is expected to commence erection at an early date. L. F. West is head.

The Vulcan Iron Works, Hudson Street, Jersey City, N. J., manufacturers of marine iron products, will commence the immediate erection of a new one-story building at its plant, replacing one of the structures destroyed by fire several months ago. It will cost about \$18,000. The company also is reported to have plans under way for the erection of other structures to replace former buildings.

The Wolis & Diamond Iron Works, 335 East Thirty-fourth street, New York, N. Y., will commence the immediate erection of a new branch plant at Whitlock avenue and One Hundred and Forty-ninth street, to be about 50x80 feet, and estimated to cost close to \$20,000.

The American Steel & Wire Company, 94 Grove street, Worcester, Mass., is planning for enlargements at its South Works, to use a fund totaling about \$100,000, being the appropriation allowed this company branch by the parent organization, the United States Steel Corporation, New York, in connection with its expansion fund of \$10,000,000, arranged to keep employees at the different mills busy during the present time.

The E. & G. Brooks Iron Co., Birdsboro, Pa., has inaugurated operations at its local sintering plant on a double operating shift. The plant was destroyed by fire some time ago and has been completely rebuilt, with the installation of new machinery and operating equipment.

The Trumbull Steel Company, Youngstown, Ohio, is now operating eight of the 12 mills at its Liberty plant, which has been idle for a number of months past. It is said that operations will be increased to include other mills at an early date.

The Electric Manganese Steel Company, Reading, Pa., recently organized, will commence operations at an early date in its new plant now being completed. The main building will be about 45x100 feet, and has been arranged to allow for the construction of an addition at a later date. The installation will comprise a large electric furnace department. Ray Houck is president of the company.

The Great Southern Steel Company, Chicago, Ill., has been incorporated under Delaware laws, with a capital of \$105,000,000, to manufacture iron and steel products of various kinds, including the operation of a blast furnace for the production of pig iron. The company is said to have acquired a large tract of land near Muscle Shoals, Ala., comprising over 100,000 acres,

and a portion of this property will be used as a site for a new plant. It is estimated that the tract contains over three billion tons of ore and over one billion tons of coking coal, to be used in connection with the development. The company is represented by Charles E. Pain, First National Bank Building, Chicago.

The Wickwire-Spencer Steel Company, Buffalo, N. Y., has increased operations at its local finishing mill to a point of about 75 per cent of normal. One blast furnace is in operation at the plant. The company also is increasing production at its different New England mills.

The Interstate Iron & Steel Company, Chicago, Ill., has increased production to about 50 per cent of normal at its local mill.

The Youngstown Welding Company, Youngstown, Ohio, has plans under way for the construction of a new steel fabricating plant on local site, comprising about 3½ acres of land, recently acquired. Preliminary work has been inaugurated. Three buildings, each about 100x300 feet, will be constructed during the coming year. The different plant departments will be devoted to plate work, boilers, tanks and kindred specialties.

The Reading Iron Company, Reading, Pa., is now operating at its puddle mill, North Ninth street, where operations have been curtailed for some time past. The Keystone blast furnace of the company was recently blown in, and plans are being perfected for the early resumption of the company's blast furnace at Emaus, Pa. The 14-inch rolling mill at the Reading works will soon be producing.

Plans are being developed for a merger of the Columbia Steel Company, Pittsburg, Cal., the Southern California Iron & Steel Company, Los Angeles, Cal., and the Carbon Fuel Company, Salt Lake City, Utah. It is proposed to increase the capitalization of the different interests and to develop plans for general plant expansion. In this latter connection, both of the plants of the two first mentioned companies will be enlarged, with the installation of new equipment, it is said, to provide for increased outputs. It is proposed, ultimately, to construct a large steel plant in the vicinity of Salt Lake City, including 500-ton blast furnace, coke ovens, etc. W. E. Creed is president of the Columbia Steel Company; A. C. Denman, Jr., president of the California Iron & Steel Company; and L. R. Rains, president of the Carbon Fuel Company.

The Commerce Steel Company, Seattle, Wash., has acquired property in the vicinity of Tekoa, Wash., as a site for the construction of a new blast furnace and steel plant. The property purchased is said to contain large quantities of iron ores, and plans will be placed under way for the construction of a blast furnace with initial rating of about 750 tons. W. C. Hayward is president of the corporation.

The Republic Iron & Steel Company, East Chicago, Ind., has reopened its local plant after a few months of inactivity. About 200 men will be employed at the present time, and which number is to be increased gradually as orders and conditions warrant.

WITH THE EQUIPMENT MANUFACTURERS

WELDING SETS UTILIZE GAS ENGINE POWER

Two types of gas engine driven welding sets, one for medium or intermittent duty and the other for heavy duty, recently have been developed by the General Electric Company, Schenectady, N. Y. Both outfits are adapted to industrial plants where the work to be done is located in odd places and is not of sufficient volume to warrant the installation of permanent equipment. Their particular field, however, is in places where electric power is not available or inconvenient or costly.

The medium duty equipment designed for intermittent duty, has a generating unit consisting of a 4-kw., 1,200-rpm., 60-20 volt, 200-ampere generator directly connected by a flexible coupling to a 4-cylinder, 4-cycle, 20-hp. gasoline engine. The engine, radiator, generator and welding panel are assembled on a cast iron base and mounted on skids. The set is 86 inches long, 28 inches wide and weighs about one ton. The engine is of the overhead valve type with the cylinders cast in block and is well adapted to intermittent service.

Practically constant energy throughout the working range is given by the generator which is self-exciting and regulating. It gives no load or striking voltage of 60 volts, which decreases automatically to the proper welding voltage, 18 to 20 volts, when the arc is struck. Driven at 1,200 revolutions per minute, it delivers a working current of 200 amperes and an output of 4 kw. The panel carries the generator field rheostat and series field dial switch by which the current can be adjusted from 75 to 200 amperes in 25-ampere steps. A reactor choke coil mounted on the set and connected in the welding circuit protects the generator from current surges.

NOVO COMBINATION HOIST AND AIR COMPRESSOR

The Novo combination hoist and air compressor was designed especially for bridge and elevated tank erection or any steel erection work within its capacity. This outfit is also useful for trench work—the hoist being used to lower and place pipe and the compressor for caulking or light rock drilling.

The outfit consists of a Novo Type TN non-reversible hoist driven by gears from a Novo 15-hp. engine. A 6x6-in. single acting compressor, driven by belt on a clutch pulley, is mounted on an extension of the channel frame.

Both hoist and compressor are equipped with friction clutches so that either one may be operated independent of the other.

The hoist is equipped with a drum for handling structural steel members. This drum holds 700 feet of ½-in. cable. The drum shaft also has a niggerhead mounted on each end for handling scaffolding, erecting derrick, etc. The drum is provided with a pin lock for disengaging drum when the niggerheads are to be used for other work.

A contracting band friction clutch is mounted on the intermediate shaft for operating the drum or niggerheads and a powerful asbestos-lined foot brake equipped with a ratchet lock is supplied to hold the load.

The compressor has a displacement of 60 feet per minute, which is ample for handling one riveting hammer, caulking, light drilling, reaming, etc. The compressor is provided with a circulating pump and a tank for cooling water. It also has a visible overflow arrangement to show the performance of the circulating pump. An unloader is provided for cutting out the compressor when the supply of air exceeds the demand. The unloader is adjustable and entirely automatic in its operation.

The crank case of the compressor is enclosed and is cast

separate from the cylinder. The latter feature does away with the replacement of almost an entire new machine in case of a brake in either cylinder or crank case, as it is only necessary to purchase the broken part.

The lower part of the crank case is filled with oil and at each revolution of the shaft the connecting rod splashes the oil on all bearings, pins, etc. This system of lubrication does away with lubricator, grease cups or oil holes.

The valves are worthy of special notice. Both inlet and discharge are made of light sheet steel; they are very light, seat quickly and quietly without wear on the cylinders and cause the machine to run practically noiseless. No springs are necessary with these valves. The areas are large so that the air can come in and go out freely, without friction. This valve construction is patented.

EXPLAINS BRIDGE CONSTRUCTION

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held at the William Penn hotel, Pittsburgh, Tuesday, December 20. S. F. Fuller, chief engineer of the John F. Casey Company, Pittsburgh, delivered a paper illustrated by lantern slides, on "The Construction of the Monongahela River Bridge at Fairmont, W. Va." The headquarters of the Engineers' Society of Western Pennsylvania now have been established in the William Penn hotel, this city. K. F. Treschow is secretary.

Upon special invitation, the members attended the meeting of the Pittsburgh section, American Institute of Electrical Engineers, held Monday evening, December 19, in the Science building, Carnegie Institute of Technology. A symposium on "Radio Telephony and Broadcasting" was conducted by the following: L. W. Chubb, Westinghouse Electric & Manufacturing Company, discussing "Radio Telephony and Broadcasting;" D. G. Little, Westinghouse Electric & Manufacturing Company, and M. C. Batsel, Westinghouse Electric & Manufacturing Company, describing "Broadcasting Transmitters" and "Broadcasting Receivers," respectively.

MASSILLON STEAM DROP HAMMER

The Massillon Foundry & Machine Company, Massillon, O., has lately redesigned its line of steam drop hammers. The housings are annealed steel castings of I section, machined to fit in deep pockets in the hammer base, which is likewise a steel casting. The cylinder is a semi-steel casting that has been reinforced over the valve. It interlocks in the tops of the housings, so that no tie-plate is required. A safety cylinder is provided to protect the hammer in case the piston rod breaks, it being so made that the piston ascends against a cushion of live steam. Any standard type of valve can be furnished. The valve bracket and the steam-inlet bracket can be removed independently of one another.

The ram guides have been arranged to adjust back into the side frames for the removal of the ram horizontally. The side frames just clear the ram, preventing over-adjustment of the guides, which would cramp the piston rod. A feature of the design is that the guide adjusting screws are threaded through nuts set in open pockets in the side frame. This arrangement permits damaged screws to be removed by cutting out the nut with an acetylene torch without disturbing the ram or guides.

FOREIGN RELATIONS

IRON FURNACE COSTS IN CHINA.

Some interesting facts and figures bearing on the cost of production of iron and steel in China, and relating in particular to the Hanyang Iron & Steel Works at Hanyang, where given in a recent issue of the *Far Eastern Review*, which is quoted here:

The iron ore, of which from 15,000 to 20,000 tons were required every month when three of the four furnaces were under operation in 1919 (perhaps another 8,000 or 9,000 tons would be needed for the fourth furnace) comes from the company's own mines at Tayeh. The cost of its production at Tayeh was below \$2.80 per ton (in 1919), but the cost of transportation per ton from Tayeh to Hanyang was \$0.85, which, together with other expenses, brought the cost up to about \$4 per ton at the Hanyang furnaces. This cost is now much lowered by smelting the ore in the new blast furnaces at Tayeh, but at the same time a greater allowance must be made for coke which has to be transported from Pinghsiang to Hanyang and thence again to Tayeh. As nearly equal quantities of coke and of ore are used in the furnaces, the saving effected in transportation is not of much significance.

Limestone also comes mainly from Tayeh. The cost per ton at the Hanyang furnaces varied in 1919 between \$2.32 and \$3.81. These figures include all transportation and overhead charges. Manganese comes from the company's mines at Changlai and Yangshin. Those two items amounted in 1919 to 3 or 4 per cent of the total cost.

The next group of items of cost concerns direct wages. This includes not only the wages of laborers working at the furnaces but also of those working at the blowing and pumping plants, both of which are essential adjuncts to the furnaces. The wages of the laborer differ not so much with the group in which he works as with the grade of labor to which he belongs. In general the laborers are divided into four grades, namely, foremen, mechanics, regular laborers, and helpers who are paid by the day. The salaries of the foremen may be in some cases as high as \$100 a month, the mechanics receive about \$20, the regular laborers from 8,500 to 9,000 cash (at the present rate of exchange between silver and copper about \$7 Mexican), and the helpers get only 200 cash a day (about \$0.15). In some cases contract labor is employed. The total cost in direct labor constitutes only 0.8 to 1.4 per cent of the total cost of iron production.

IRON AND STEEL PRODUCTION IN RUSSIA.

"During the years 1917 to 1920 Russian industry and transportation drew their metals from the old sources of supply, which accounted for their ability to carry on their usual activities," states the *Pravda* (Moscow) in a recent issue, and continues:

At the beginning of 1921 it was evident there were very small stocks of metals in the State warehouses, while some of the most useful were entirely lacking. Most of the difficulty prior to 1920 was experienced because of a shortage of fuel, while during the year 1920 it was due to a scarcity of labor and in 1921 to a shortage of raw materials.

For the first quarter of 1920 instead of 2,334,000 poods (pood = 36.1128 pounds) of pig iron required by the Government's program, only 2,144,000 poods were smelted, or 95 per cent of the program. The central region produced 302,000 poods, or 39 per cent of its allotment; the southern region, 270,000 poods, or 108 per cent; and the Ural region, 1,572,000

poods, or 119 per cent.

The production of Martin steel during the first quarter of 1921 declined to a mere 6 per cent of that before the war. In all three regions production aggregated 2,926,000 poods, while in the corresponding quarter of 1913 a total of 51,737,000 poods was turned out.

For the first quarter of 1921 the central region produced 476,000 poods of rolled steel, or 57 per cent of its allotment; the southern region, 720,000 poods, or 120 per cent; the Ural region, 1,290,000 poods, or 81 per cent; a total for all three districts of 2,386,000 poods, or 87 per cent of the Government's program.

NEW BRIDGE FOR SYDNEY, AUSTRALIA.

Specifications to cover the design, construction, and erection of the Sydney (Australia) Harbor North Shore Bridge are expected shortly by the Bureau of Foreign and Domestic Commerce from Trade Commissioner A. W. Ferrin, and upon their receipt copies will be placed on file in the Bureau's New York and Chicago offices, where they may be consulted by interested persons.

The bridge will consist of nickel-steel cantilevers supporting a central girder section, also constructed of nickel steel, spanning the harbor between Dawes Point and Milson's Point. Each anchor or shore arm will be 500 feet long, the harbor or cantilever arms will be 520 feet long, while the central section is to be 560 feet long, thus making a span of 1,600 feet from center to center of the main supporting piers and a total length of steel work of 2,600 feet. Between the main girders, which are 94 feet 6 inches apart, provision is made for four lines of electric railway and a roadway 35 feet wide. Outside the main girders on the east side is a motor roadway 18 feet wide between the handrails, and on the western side a footway 15 feet wide, the railways, roadway, and footway being all on the same grade. A headway of 170 feet above high water is provided for the central 600 feet of the bridge, with a clearance of not less than 156 feet over the whole fairway.

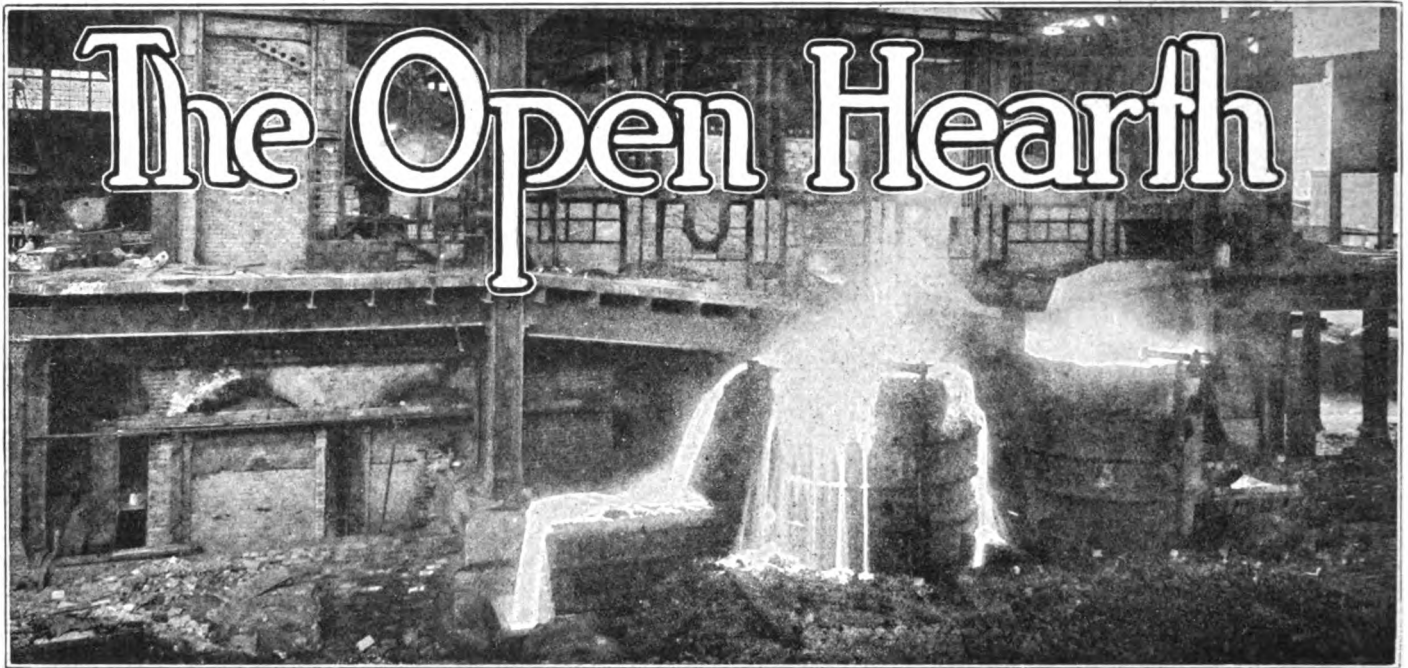
The Sydney Harbor bridge will thus have 5 feet greater span and 35 feet more headway under the center than does Brooklyn Bridge, and will have a span only 200 feet shorter than that of the Quebec Bridge, but with a headway 20 feet greater. The estimated cost of the bridge is £6,000,000, and the work is expected to extend over eight and a half years.

Several new steel companies are in process of organization in China, the *Far Eastern Review* reporting the organization of the Wu-Shun Steel & Iron Works, of Shanghai, an Anglo-Chinese enterprise, and a steel refining works to be erected by a Shanghai merchant.

FRENCH STEEL OUTPUT FOR SIX MONTHS.

Consul Ernest L. Ives, Paris; see also Commerce Reports for Nov. 28, 1921.

The total production of steel ingots and castings in France during the first six months of 1921 amounted to 1,537,634 metric tons, 1,487,961 tons of which were ingots, and 49,673 tons of which were castings, according to statistics compiled by the *Comite des Forges de France*. There is an increase of 332,933 tons in the production as compared with January-June (1,204,701 metric tons) and a decrease of 308,061 tons as compared with July-December of 1920 (1,845,695 metric tons).



Edward Heldt has been made general manager of the Lincoln Foundry Company recently organized at Merrill, Wisconsin. Mr. Heldt, for twenty years, was connected with various Wisconsin and Minnesota shops.

✓ ✓

Walter Ferrier resigned his connection with the Elyria Iron and Steel Company, Elyria, Ohio, and Cleveland, to become general manager of works of the new Hudson City Steel Corporation, Beacon, New York. Mr. Ferrier was with the steel corporation plants at Homestead, Pa., and Gary, Ind., for eighteen years and later for seven years with the Cambria Steel Company, at Johnstown, Pa.

✓ ✓

A. D. Miles, president of the International Nickel Company of Canada, subsidiary of the International Nickel Co., New York, has resigned, together with G. E. Sylvester, assistant to the president, and W. M. Dennett, assistant treasurer, due to the depression in the industry which resulted in suspensions of the company's mining and smelting operations.

✓ ✓

Horace B. Spackman was recently elected president of the Eastern Pig Iron association. Mr. Spackman is both a producer and a buyer of pig iron. He is president of the Allegheny Ore & Iron Co., which has blast furnaces at Buena Vista and Iron Gate, Va. The company is owned by the Lukens Steel Co. Mr. Spackman also is second vice-president and purchasing agent of the Lukens Steel Company, which is the most important buyer of pig iron in the East.

✓ ✓

Thomas J. Collins, for many years auditor of the Page Steel & Wire Co., Adrian, Michigan, has resigned.

✓ ✓

J. T. Rose was recently appointed collector of internal revenue for Georgia. Mr. Rose is vice president of the J. B. McCrary Co., Atlanta, industrial engineers, and formerly vice president of the Atlantic Steel Co., Atlanta.

✓ ✓

Stewart M. Marshall of the engineering firm of Perin & Marshall, New York, arrived in Japan recently on a trip to India. He expects to spend some time in China.

✓ ✓

Frank Carroll has resigned as chief draughtsman of the Youngstown Sheet & Tube Co., Youngstown, Ohio, to be-

come assistant to the chief engineer of the Inland Steel Co., Chicago.

✓ ✓

R. L. Wahl, chief engineer of Inland Steel Company, Indiana Harbor, Ind., has been appointed acting general superintendent of mines for the company during the illness of William Wearne.

✓ ✓

Wilbert L. Smith of Syracuse, N. Y., has been elected director of the Crucible Steel Co. of America, New York and Pittsburgh, to succeed John W. Daugherty, who retired as a director at the company's annual meeting held in Jersey City, N. J., recently.

✓ ✓

Charles Wilson was recently promoted assistant superintendent of the Enterprise Foundry Co., Auburn, N. Y. He has been with the company four years.

✓ ✓

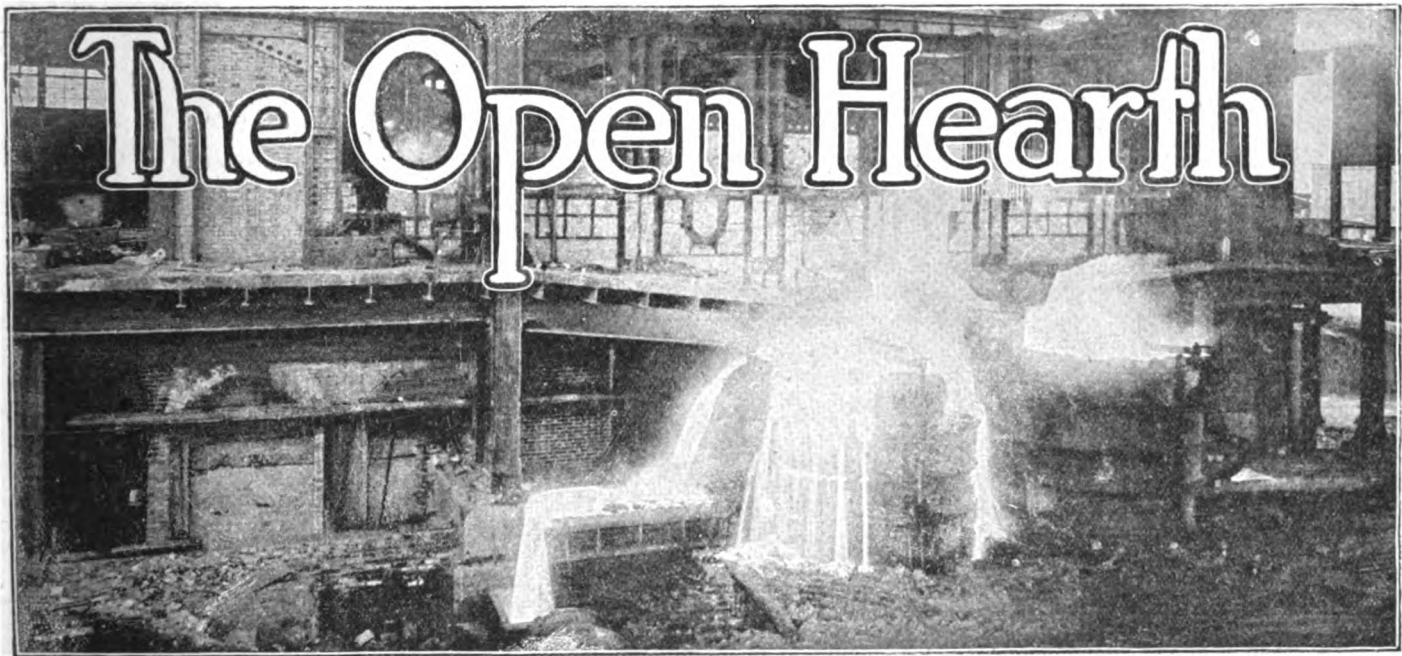
G. W. Wrenshall has been appointed general manager of the Pressed Steel Car Company, Pittsburgh, in succession to the late J. B. Rider. Mr. Wrenshall was general superintendent of the McKees Rocks plant of that company since 1909. Since Mr. Rider's death, Mr. Wrenshall has been acting as manager. Henry P. Hoffstot, president of the Koppel Industrial Car & Equipment Co., Pittsburgh and Koppel, Pa., a subsidiary of the Pressed Steel Car Company, who was recently elected vice president of the Pressed Steel Car Company, has assumed the vice presidential duties formerly discharged by Mr. Rider. Mr. Wrenshall has had considerable experience in the car building industry, having been affiliated for 12 years with the Southern Car & Foundry Co., as manager and the Western Steel Car & Foundry Co. as superintendent, both at Anniston, Ala.

✓ ✓

A. A. Albaugh, formerly general superintendent Jacobson Machine Mfg. Co., has been appointed vice president and general manager of the Barnhart-Davis Co., Warren, Pa., iron and brass works.

✓ ✓

Charles H. Bromley, formerly technical director Richardson-Phenix Co., Milwaukee, Wisconsin, is now manager and chief engineer of the newly formed Richardson-Phenix division of S. F. Bowser & Co., Inc. This division will con-



duct the filtration and lubrication appliance business of the consolidated companies, with main office at Fort Wayne, Ind.

V V

Henry D. Hibbard, consulting metallurgist, Plainfield, N. J., sailed on November 30th for a sojourn in southern France and Italy.

V V

A. G. Labbe has been elected president of the Willamette Iron & Steel Works, Portland, Ore., succeeding Bert C. Ball, who will devote his time to other interests, chiefly to the Portland Vegetable Oil Mills Co. E. C. Pape, second vice-president, was advanced to first vice-president to succeed Mr. Labbe. N. H. Insley was chosen secretary and H. V. Carpenter treasurer.

V V

E. A. Wheaton was recently promoted to the position of open hearth superintendent of the Bethlehem Steel Corporation, Sparrows Point plant at Maryland, to succeed F. F. Lines who resigned a short time ago. Mr. Wheaton was formerly superintendent of open hearth department No. 3, Lehigh plant of the above named company, and was graduated from Lehigh University in 1912. He entered the employ of the Bethlehem Steel Corporation following his graduation as a metallurgical engineer. At the meeting of the American Iron and Steel Institute, October, 1920, he read a paper on "High Manganese Iron in Basic Open Hearth Practice."

V V

W. J. Priestly, metallurgical engineer, United States Naval Ordnance Plant, South Charleston, W. Va., has been chosen chairman of the Board of Registration for Engineers of West Virginia, the body set up by an act of the Legislature. George E. Taylor, Anderson & Taylor, consulting engineer, Charleston, has been elected secretary of the board, the other members of which are Frank Haas, Fairmont, consulting engineer, Consolidation Coal Co.; H. C. Cooper, Clarksburg, general superintendent Hope Natural Gas Co., and N. H. Mannakee, Bluefield, consulting mining engineer.

V V

E. M. Freeland recently resigned his position with the Sparrows Point, Md., plant, the Bethlehem Steel Corporation to become affiliated with Follansbee Brothers Company, as metallurgist at the company's plant at Follansbee, W. Va.

V V

E. T. Vogel was recently elected vice president of the Eastern

States Furnace and Coke Oven association. Mr. Vogel is superintendent of the Youngstown Sheet & Tube Company, Youngstown, Ohio.

V V

E. D. Batchelor, district sales manager in St. Louis for the Jones & Laughlin Steel Company, has been made manager of sales of that company's wire department at Pittsburgh, effective January 1, upon the retirement of Mr. Mason. Mr. Batchelor has been with the company more than 32 years, serving first in several departments in the general offices and for 10 years attached to the Pittsburgh sales district. For the past 10 years he has been manager of the St. Louis district.

V V

John A. Denholm, vice president and assistant general sales manager of the Wickwire Spencer Steel Corporation, and Albert B. Fritts, advertising manager of the Norton Company, both of Worcester, Mass., have been elected president and vice president, respectively, of the Worcester Commercial Travelers' association.

V V

John Bindley, chairman Pittsburgh Steel Company, Pittsburgh, and for more than 50 years identified with the hardware and steel industries, died at his winter home, El Jardine, Miami, Fla., December 16, death being due to disabilities of age. Prior to becoming chairman of the company, Mr. Bindley had been its president, having been elected in March, 1919, to succeed the late Wallace H. Rowe. He was born in Pittsburgh 75 years ago and had always lived in that city, his larger interests always having been centered in the Pittsburgh district. At the age of 16 he entered the employment of John England, who conducted a hardware store and file factory in Liberty street, near Ninth street. Upon reaching his majority, he became a partner in the business, under the firm name of John England & Co., which later was changed to England & Bindley. A few years later Mr. Bindley purchased the interest of Mr. England, and the firm name was changed to the Bindley Hardware Company. The company was liquidated in 1910. While engaged in the hardware business he became interested in manufacturing, first in the Neely Nut & Bolt Company, of which he was president at the time of his death, and in 1901 in the Pittsburgh Steel Company, of which he was one of the organizers and an original director. Upon the death of his brother, Edwin Bindley, in 1906, he succeeded him as vice president of that company. He was also one of the organizers and a director of the Pittsburgh Steel Products Company.

PRODUCTION TOPICS

A NEW IDEA IN STEEL IDENTIFICATION AND STORAGE

It often happens that, due to an absence of standard equipment on the market or lack of a standard way of doing things, manufacturers are forced to create new methods or devise new equipment that will exactly fit into their particular system of operation, with the result that the new idea evolved and executed is generally an improvement over everything of a similar nature that has preceded it.

Such a condition caused the firm of Gould & Eberhardt to devise the following method of marking their steel bars for identification and also designing and constructing suitable steel storage racks to conform with the highly developed manufacturing system employed in their new plant at Newark, N. J.

Several new ideas in steel marking, together with a novel design in storage racks, is the result of their efforts to solve their own factory problems.

In the manufacture of shapers and automatic gear cutting machinery, they naturally use many different kinds and sizes of steel bars—round, square, hexagon, and rectangular in shape, so this convenient system of storing and marking the various grades and sizes entirely eliminates the possibility of an error in finding the required piece.

Plain colors and combinations of colors play an important part in the scheme of marking the steel, each color having a direct significance with regard to the metallurgical contents or the particular make of steel. The identification colors are painted on the ends of the bars as they are received in the shipping department.

To assist the raw material clerk in selecting the proper steel, a very noticeable identification board is hung above each rack. On this rack are listed all the different kinds of steels the company uses, with a two-inch disk, painted in the corresponding color, opposite each name. The board has a wide background which shows the various colors to great advantage.

The various steels with their corresponding colors as listed on the board are:

30/45 machine	red
High speed tool	blue
Crescent	yellow
10/15 machine	green
Cold rolled	white
O. C. N. S.	Halves of green and red
Simplex.....	green with white stripe
Tap.....	Halves of green and white

Each rack is built up of five duplicate sections, spaced four feet apart and properly braced to form a very rigid rack 16 feet long, the entire rack being bolted together with $\frac{1}{2}$ -inch bolts.

The individual section has a base consisting of a heavy 8-inch I beam 8 feet long, with 6 heavy 2x2-inch angles, 7 feet high, equally spaced and forming uprights to divide the section into five tiers. These tiers are in turn subdivided by $\frac{1}{2}$ -inch rods which extend from top to bottom, thereby making 10 tiers available in each rack.

Cross pieces or shelves on which the steel bars lay are heavy 2x2-inch angles, spaced about 20 inches above each others at the bottom and diminishing in this distance until at the top, where the very small rods are stored; the distance between is about 6 inches. The top piece of each section is composed of a heavy 2x3-inch angle, making a very rigid top brace to complete the

frame of the section, and also permitting the storage of extra large diameter short bars on top of the rack.

The five cross sections are spaced and held together to form the completed frame work of the rack by 2x2-inch heavy angle stringers extending the full length of the rack at the top and bottom of each side.

Extra longitudinal bracing is provided by $\frac{1}{4}$ x2 $\frac{1}{2}$ flat bars crossed between and bolted to the top and bottom of the sections.

An extra angle on each side at the top and extending the length of the rack prevents pieces from rolling off, while further precaution is taken by having timbers with half round notches cut in them extending along the front on top of the rack, permitting short round pieces to be laid in place.

Naturally, the most convenient way to place the steel in the rack would be to have all the steel of the same kind in one tier with the largest and heavier pieces on the bottom and the varying sizes in regular order, according to their dimensions, with the smallest at the top. This order has been reversed wherever possible, in some cases the square, hexagon, or rectangular shaped bars, which are generally smaller in size, being placed on the bottom shelves, and the very heavy bars on the very top so that they may be easily handled with the traveling crane which travels above these racks.

In order to facilitate the placing and location of the various kinds and sizes of steels into their proper places, each rack is given a section number, besides each tier in the rack is lettered and each shelf is numbered, making it a very simple matter to give instructions for the proper location of each bar as it is received, besides assisting to keep stock records and taking inventory.

Much thought has been given to the general design of the rack and also the system of storage employed, both perhaps embodying all the desirable features that Gould and Eberhardt have found to be correct during their 88 years of manufacturing experience.

BIBLIOGRAPHY ON REFRACTORIES.

The Refractory Division of the American Ceramic Society has issued a new bulletin in the form of a bibliography of magnesite and dolomite refractories. Organizing Secretary Ross Purdy, Columbus, Ohio, has collaborated with A. S. Greaves-Walker, chairman of the division.

This is but the first of the bibliographies to be issued by the society. The Refractory Division will shortly issue other bulletins on chromium, sillimanite, alumina, spinel, silicon carbide, zirconia, carbon, clay and special refractories including nitrides and oxides. The U. S. Bureau of Mines, in Columbus, is collaborating in the preparation.

LARGEST ELECTRIC STEEL MELTING FURNACE.

The Ford Motor Co. has placed an order for the largest electric steel melting furnace ever designed. Its capacity will be 9000 kva, which is claimed to be three times the size of any previously installed furnace. It will have six electrodes and will be of the Greaves-Etchells bottom conducting type, sold by the Electric Furnace Construction Co., Philadelphia. This furnace will be the principal melting unit of the new battery of electric furnaces for the Ford company's River Rouge works.

PRODUCTION TOPICS

GROUND TO BE BROKEN FOR COLD-ROLLED STRIP MILL AT BEACON, N. Y.

Ground will be broken at Beacon, N. Y., the first week in January for the cold-rolled strip mill of the Hudson City Steel Corporation, the plans of which were published in "The Iron Age" of August 19, 1920. It will roll strips from 2 to 14 in. wide and from 0.01 to $\frac{1}{4}$ in. thick and will sell to the general trade. The corporation owns another site at Hudson, N. Y. It is the plan to first manufacture strips, later building open-hearth furnaces thereby making it unnecessary to buy billets and sheet bars.

The mill will have a cold-rolled strip capacity of 1000 tons per month on a 10-hr. day. The equipment will consist of five 10-in. mills, five 12-in. mills, two 25-ton General Electric annealing furnaces, two slitters and two straighteners. Dwight P. Robinson, Inc., New York, will erect the building and install the equipment. Offices of the Hudson corporation are at 2302-4 Woolworth Building, New York, in charge of James S. Landers, vice-president and general manager. The corporation was formed in May, 1920, the capitalization being \$500,000.

ELECTRICAL REVIEW OF THE STEEL INDUSTRY DURING 1921

By O. NEEDHAM, General Engineer

Westinghouse Electric & Manufacturing Company

The activity in the steel mills during 1921 has not been very great, and therefore there has not been a considerable amount of extension work or new building in connection with them. There has, however, been some quite notable advances made by electricity in the steel mills.

The installation of a reversing motor to replace a reversing engine on the 44-inch blooming mill of the Bethlehem Steel Company at Steelton, Pa., marks the first time that electricity has replaced steam on a reversing blooming mill in this country. Only 23 days elapsed from the time the engine was taken out of service until the motor was put into service. On the third day of operation with the electric motor the mill rolled 1,006 tons on a turn, which was within 40 tons of being the record with the engine. Since then the mill has rolled 1,520 tons on a turn.

Another instance of electricity replacing steam for driving a reversing blooming mill is at the Atlantic Steel Company, Atlanta, Ga. A reversing motor was installed and placed in operation during May and the first part of June, 1921, on a blooming mill, this motor replacing a reversing steam engine.

The Follansbee Brothers have installed in their new plant at Toronto, Ohio, a reversing motor to drive a bar mill. This is the first instance in this country of a reversing motor being used to drive a bar mill. This mill will be used for finishing sheet bar.

A very interesting installation from an electrical standpoint will be the new electrically driven mills of the Driver Harris Company at Harrison, N. J. This installation will consist of a 20-inch mill and a 9-inch mill, each driven with an adjustable speed d.c. motor operated at 600 volts and supplied with power by a common motor generator set. The motor generator set consists of a synchronous motor and a d.c. generator. The point of special interest in this installation is its automatic features. The motor generator set is started up and put on the 2200-volt, 60-cycle circuit by the mere pressing of a push button. The motor generator set, as well as the two mill motors, are equipped

with bearing thermostats, and thermal relays are placed in the circuits of all the machines. These thermostats and thermal relays are so connected up that if a bearing temperature rises above a predetermined value or a circuit becomes too much overloaded, they will ring a gong to warn the mill operator. The gong as well as the start and stop push buttons and the meters for the motor generator set and mill motors are placed in the mill pulpit. No attendant is required for the motors and motor generator set, as complete and positive protection is given the equipment by the automatic protective devices.

The Missouri Rolling Mill Corporation recently purchased two adjustable speed d.c. motors to drive a 16-inch and a 9-inch mill. These motors operate from a rotary converter, which receives power from a 13,200-volt, 25-cycle circuit. This installation as well as the Driver Harris Company mill will operate with central station power.

Central station power is used very extensively in the smaller plants and to some extent in a number of the larger ones. Most of the larger companies generate the greater part of their power so that some steel companies have generating station that compare quite favorably with some of our central stations. This means that they are able to utilize some rather large units and thus obtain economies comparable with central stations. The tendency in steel mills is toward the higher steam pressures and superheat used by central stations. Steel mill stations now use up to about 20,000 kv.-a. operating on 225 lb. steam and 150 deg. superheat.

The question of yard electrification for steel mills has been receiving considerable attention. There has not been any yard electrifications in steel mills up to the present time, but considerable investigation has been going on and it would appear that there is a very fertile field for electrical development in this direction.

Electric energy for heating is opening up an additional field for the use of electricity in steel mills. A number of instances, such as electrically heated babbit and solder pots, tin pots for tin mills, heat treating ovens, and core drying ovens for foundries are proving successful and demonstrate that electricity can be used in this field.

SHIPPING STEEL ON OHIO RIVER.

Recent shipments of iron and steel from Pittsburgh and various cities along the Ohio River which have the necessary terminals have caused much comment among local business men, the products carried on these trips not being available to Cincinnati because of the difficulty of transferring them from barges to trucks or other vehicles. With proper terminal facilities much business that now goes to other cities would come to Cincinnati and at the same time local consumers would get the benefit of the lower space rates offered by the waterway carriers.

Several plans for terminals have already been worked out by engineers, and it is expected that early action will be taken to build river terminals at some advantageous point on the river front to take care of the ever-increasing shipments of heavy bulk freight into the city. The Chamber of Commerce is active in promoting a concerted effort to this end among the business interests.

TRADE NOTES

On December 15th, the New York Office of the Blaw-Knox Company, was moved from the City Investing Building to the Carbide & Carbon Building, 30 East 42nd Street.

As of December 1st, the Andrews-Bradshaw Company, Sales Engineers, formerly located on the third floor of the B. F. Jones Bldg., Pittsburgh, Pa., have moved to the eighth floor of the same building. They have, by this move, doubled their office space.

Mr. A. D. Keene, Electric Furnace Engineer of the General Electric Company, Schenectady Works, is now connected with the Pittsburgh Electric Furnace Corporation as engineer on electric furnace designs and applications in the steel and metal industries.

The Engineering Advertisers Association of Chicago is now publishing a monthly bulletin in the interest of its members. The Bulletin gives a digest of the speeches made at the various meetings and also includes other information and facts regarding the movements of goods from industry to industry, personal notes, etc. We are advised that at the present time there are a limited number of extra copies of the "Bulletin" which will be sent upon request to the advertising managers of concerns selling technical or engineering products.

William Swindell & Brothers, of Pittsburgh, Pa., have established an electric furnace department under the direction of Frank W. Brooke, late vice-president and chief engineer of the Electric Furnace Construction Company, Philadelphia, Pa. This department offers the latest design in furnaces for melting steel, gray iron and non-ferrous metals, and also a complete line of electric heating furnaces from 30 kw upwards. A license to operate under the Marsh Patents has been granted to this firm.

Whiting Corporation, Harvey, Ill. (Chicago Suburb), has purchased a controlling interest in the Grindle Fuel Equipment Co., manufacturers of Complete Powdered Coal Plants for use in connection with malleable furnaces, annealing ovens, steam boilers, billet heating and various other types of furnaces.

F. J. Ryan & Company, Wesley Building, Philadelphia, Specialists in Industrial Furnace Problems announce the award of a contract from the City of Philadelphia for all of the equipment in the new Forge

and Foundry Shops of the Water Department.

Freyn, Brassert & Company, Chicago, have recently shipped boiler and hot blast stove burner equipment to the Rochester & Pittsburgh Coal and Iron Company at Punxsutawney, Pa., and the Chateaugay Ore & Iron Company at Standish, N. Y. The Shenango Furnace Company has recently installed this company's Mathesius hot blast gate valve equipment. Freyn, Brassert & Company have also been retained by the Mitchell-Diggings Iron Company, Cadillac, Mich., in reference to power plant matters.

Bell & Gosset, Chicago, representatives of the Quigley Furnace Specialties Company, 26 Cortlandt street, New York, have been succeeded in that capacity by H. M. Thompson, formerly with the Thomas Moulding Brigg Company, Chicago.

Pittsburgh offices of the R. H. Beaumont Company, Philadelphia, contractor of coal, coke and ash handling systems, are to be moved from 230 Fifth avenue to the Oliver building. Charles W. Ross is the new manager of the Pittsburgh office.

Toronto offices of the International Nickel Company of Canada have been closed and executive business of the company has been transferred to the offices of the International Nickel Company, New York.

New sales offices at Dayton, Ohio, of the Wyckoff Drawn Steel Company, Pittsburgh, are located at 1126 Reibold building in charge of George H. Rehling, who also has charge of the southwestern Ohio territory.

TRADE PUBLICATIONS

The Machine Tool Division of Pawling & Harnischfeger Co., of Milwaukee, has just issued Bulletin 4-F, describing the new Horizontal Boring, Drilling and Milling Machine, which was recently described in detail in this publication. One of the interesting illustrations included in this Bulletin shows how all operating levers are concentrated on the saddle. A circle with 20-inch radius includes all these levers, giving a good idea of the compactness and convenience of operation.

An outline of the fundamental principles of heating and handling, so frequently overlooked in practice, with illustrations of their practical application in the manufacture of wide variety of

springs, are carried in Bulletin No. 240—"The Heat-Treatment of Springs with Stationary and Continuous Furnaces,"—published by the W. S. Rockwell Company.

The Electric Furnace Company, manufacturers of the Bailey electric furnace, have issued a descriptive bulletin showing a large number of Bailey installations. It is a very attractive bulletin.

Ingersoll-Rand has published Bulletin I-R, Surface Condensers, which describes a recent highly important development of this type of condenser and also describes Barometric and Low Level Multi-jet types of condensers, manufactured by the same company. It vividly describes the use of surface condensers.

The Laclede-Christy Clay Products Co. have published a bulletin in which is included an article on "Are Refractories Imposing a Limitation on Stoker Performance?" This article contains worth while information which is of interest to the engineers in charge of plants, particularly those who have charge of the buying of refractories for power plants. A booklet will be sent upon request.

M. H. Treadwell Co. have issued a booklet entitled "Mixer Type Hot Metal Cars." This booklet is descriptive and contains photographs of many of these cars which are now used by prominent steel plants. Among the large users of this type of metal cars are the Cambria Steel Company, who have ten 75-ton cars and Jones and Laughlin Steel Company, who have nine 80-ton cars.

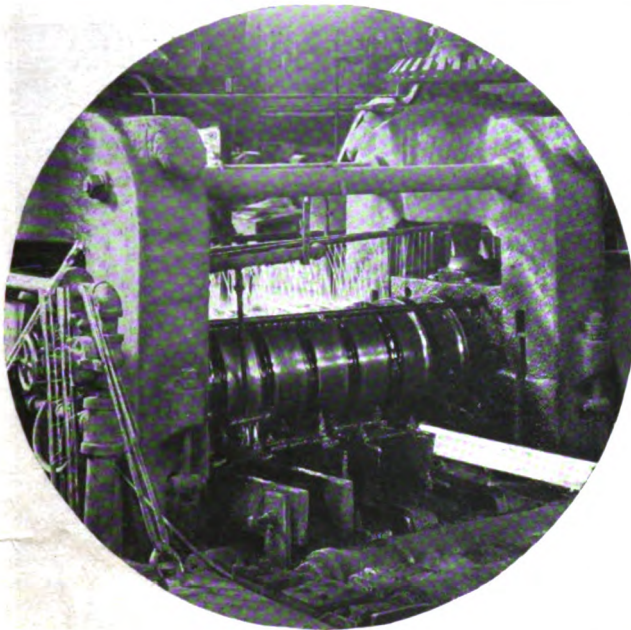
Book No. 113 issued by the Industrial Works, Bay City, Michigan, is descriptive of the Crawling Tractor Cranes. It shows various types of cranes which are used around industrial plants to the best advantage.

The Edge Moor Iron Company has issued a book under the title of "The Development and Theory of the Water Tube Boiler." It is very interesting and covers the subject completely.

Industrial Works, Bay City, Mich., is distributing free upon request Catalog No. 113, illustrating and describing the Type BC "Industrial" crawling tractor crane of 20,000 pounds capacity. This crane is pre-eminently adapted to the needs of road contractors, lumber and coal dealers, gravel, sand and stone producers, foundries, railroad reclamation and storage yards, and moderate size manufacturing plants.

The Blast Furnace *and* Steel Plant

Pittsburgh, January, 1922.



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